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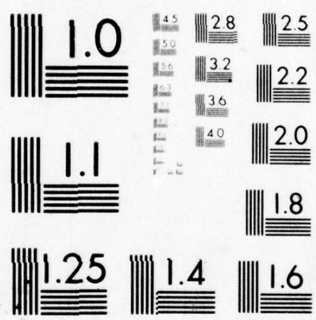

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EDITOR'S PREFACE

This issue of Problems of the North reviews the question of development and its effect upon the environment under three broad headings:

(1) The influence of economic development on the natural environment of the North;

(2) Regional aspects of conservation in the North; and

(3) Problems of resource development in the North.

I should like to thank the Department of Indian Affairs and Northern Development for its financial support and assistance in reviewing all the articles in this issue. The Canada Institute for Scientific and Technological Information, National Research Council of Canada, deserves special mention for providing the much-needed staff and funds to publish this translation. In particular, I am especially indebted to Mr. G. Belkov for editing the translation, to Miss A. Cowan for co-ordinating various aspects of the publication, and to Mrs. Joyce Dagenais and Miss Fina van der Veen for the final typing.

R. J. E. Brown,
Chairman,
Editorial Board.

GLOSSARY

This glossary includes Russian terms which occur in English technical literature but which may be unfamiliar to some readers of "Problems of the North", e.g., "kolkhoz", "oblast", "krai". It also includes highly specialized terms like "sor", terms which may not convey the right meaning in the translated form, e.g., "subsidiary farm", and Russian measurement units and their English equivalents.

__bukhta__ - a small bay suitable for anchorage.

__centner__ - 220 lbs.

__centners/ha__ - 90 lbs/acre.

__chum__ - a portable dwelling of the Saami, Nentsy, Evenki, Mansi, and others; conical in shape and made of poles covered with reindeer skins or bark.

__farm__ (ferma) - an animal husbandry unit with very limited lateral integration, e.g., dairy farm, poultry farm, fur farm; operated by a kolkhoz, sovkhoz, or some other authority.

__gospromkhoz__ - an economic unit based on hunting, fishing, gathering and small-scale logging and lumbering. Gospromkhozes are set up to exploit the biological resources of areas which are too sparsely populated to form kolkhozes.

__guba__ - a gulf or bay, primarily on the northern and eastern coasts of the U.S.S.R.

__hectare__ - 2.47 acres.

__kilogram__ - 2.2 lbs.

__kolkhoz__ - a collective economic unit, based on the artel principle, for the exploitation of biological resources. Kolkhozes receive long-term allocations of land comprising (in the North) any combination of agricultural land, reindeer pastures, fishing grounds and hunting ranges. Kolkhoz members receive payment in kind, and in money from the net income of the unit derived from the compulsory sale of a certain percentage of its output at fixed prices.

__krai__ - largest administrative unit in the R.S.F.S.R. primarily in Central and Eastern Siberia and equivalent in political and administrative structure to a territory.

PROBLEMS OF THE NORTH

Translation of "Problemy Severa"

No. 18, 1973 Translation, December 1976

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VI. COMMUNICATIONS AND INFORMATION

SPECIFIC ASPECTS OF ENVIRONMENTAL PROBLEMS IN THE NORTH UNDER CONDITIONS OF INDUSTRIAL DEVELOPMENT

(In lieu of a Foreword)

Modern industrial development, which has brought about a growth of the urban population and an increase in the number of large towns and cities, has raised the problem of environmental protection as one of the major concerns of our day. And the failure to apply the achievements of science and technology toward protecting the atmosphere, the land and its mineral wealth, the forests and water, the animal and plant kingdoms, may have grim consequences for mankind.

Suffice it to mention that in the United States of America the annual release of soot into the atmosphere is over 140,000,000 tons, and that the waste from the construction industry alone amounts to about 3,000,000 tons. A. Arakelyan, an Academician of the Armenian S.S.R., reports in his article based on data published by "McGraw-Hill", that in 1972 the cost of water and air purification in the U.S.A. was $5 billion, while the capital required for this purpose was estimated in tens of billions of dollars ("Izvestiya", June 4, 1973). Similar phenomena have also been observed in other countries.

The amount of sulphur anhydride released into the atmosphere throughout the world amounts to hundreds of millions of tons a year, that of nitrogen oxides to about half that figure.* As a result of man's misguided interference, the balance of nature has been disturbed in a number of aspects. Though negligible thus far, an increase of the carbon dioxide content in the atmosphere has already been recorded. Should we fail to arrest this process, it will contribute to a change of climate on the earth. Dust pollution of the atmosphere inhibits the passage of solar energy, while the growing content of carbon dioxide in the atmosphere retains the heat near the earth's surface. All this may lead to a significant rise in temperature of the bottom layers of the atmosphere.

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* A. Vinogradov. Zhivoi pokrov planety (The living cover of our planet). "Pravda", June 5, 1973.

Problemy Severa, (18): 3 - 10, 1973.

From the very first years of the Soviet regime attention was focused in our country on the need to manage natural resources carefully in the course of their exploitation, and environmental protection legislation was adopted. These legislative acts have been improved throughout the years of our State's existence, and environmental protection represents an organic part of our national economic planning. In the U.S.S.R. admissible concentration standards, representing no hazard to human or animal health, have been established for 400 substances, including 120 noxious substances and 25 combinations of such substances in the atmosphere. The Soviet government pays a great deal of attention to environmental protection in large cities. For example, in Moscow around 700 hazardous enterprises have been moved outside the city limits and over 7,000 purification plants have been built. As a result of the measures introduced, the air in Moscow has become cleaner.

In the resolutions of the XXIV Congress of the Communist Party of the U.S.S.R., particular emphasis is placed on directives concerning environmental protection. The resolutions of the September 1972 session of the Supreme Soviet of the U.S.S.R. and the Decree of the Central Committee of the Communist Party of the U.S.S.R. and of the Council of Ministers of the U.S.S.R. "To strengthen environmental protection and to improve the exploitation of natural resources" determine the paths for solving the complex problem of environmental conservation and improvement under conditions of steadily increasing industrialization within the country. In the agreements concluded by the Soviet State with the United States of America and Canada a special place is reserved for the problems of environmental protection and for joint national efforts in that area.

It must be kept in mind that there is but one atmosphere and that noxious substances discharged in one place are transported over large distances to other seemingly remote territories, and that the oceans and the seas of the earth are interconnected. Harmful liquid and solid waste released into rivers passes into the seas and oceans. Furthermore, the seas and oceans themselves become polluted as a result of the noxious waste being dumped by thousands of tanker, freight, and passenger vessels cruising over them. Given the steadily growing rate of industrial production in all regions of the world, environmental protection is becoming more than ever the most urgent problem of global importance. In recent years a great deal of attention has focused on it throughout the world.

Environmental protection is the greatest socio-economic problem of modern times. The cost of antipollution devices often reaches one third of the investment in basic production facilities. In this area science is only beginning to develop momentum in devising novel means for reducing this cost. But the cost will remain very high for a long time to come. Moreover, given the growing rate of industrial development, the unit share of this investment will increase in the foreseeable future. Expenditures related to ecological factors should therefore be estimated in all economic calculations of capital investment efficiency as carefully as conventional factors.

The literature dealing with ecological problems contains a suggestion to develop closed-cycle enterprises, where all the substances contained in the raw material and in the fuel are utilized, leaving no hazardous waste or releases into the biosphere. This requires a fundamentally new technology for all the types of enterprises, particularly for the pulp and paper industry, ore-dressing plants and many chemical enterprises discharging particularly harmful waste. The introduction of this type of technology should raise the economic efficiency of capital investment not only as a result of fully utilizing all the useful components found in the natural raw material, but also because it would sharply reduce or even eliminate the cost of decontamination devices.

Examples of this technology are already in existence. For example, waste-free meat-processing plants have been developed. On the whole, however, this is a problem for the future. Many years will elapse before closed-cycle enterprises are developed and before the entire industry has been converted to the new technology. Meanwhile, in planning our economic development particular attention should be paid to environmental protection hand-in-hand with the development of a waste-free technology, and its incorporation into newly built enterprises.

There are substantial differences between the problems of environmental protection within temperate climatic zones or in the South where some 97% of our country's capital stock and industrial production are concentrated, and in the North, where both the share of capital invested in industry and the population figures are still fairly low, but where the problems of environmental

protection have certain distinctive aspects and are no less acute than in industrially developed regions.

Their specificity is rooted in the fact that, as may be seen from the papers published in this issue, nature is much more vulnerable in the northern territories than in the more southerly situated regions. Ecosystems are simpler in the North than in the regions marked by a temperate climate, or in the South; they are therefore more vulnerable and less stable. The scale of industrial development in the North is still relatively small (as compared to the industrially developed parts of the country) and there is ample opportunity to forestall the disturbance of its ecosystems. To do so, their distinctive characteristics must be studied, and the achievements of science and technology must be directed toward preventing disturbances and, wherever possible, improving the environment. It is highly important that industrial development is realized in the North in localized foci and territorially is confined primarily to the localities marked by concentrations of natural resources. It enables us to implement the necessary measures more effectively in relatively small areas, while taking steps towards protecting large territories of "industrial void" by simpler means.

Another important peculiarity of the North with respect to ecology is the development of a number of enterprises particularly hazardous to the environment. For example, the predominant development of extractive industries, among which the recovery of oil and natural gas is steadily gaining in importance, is a feature characteristic of the North. As is well known, oil has a particularly harmful effect on nature. It cannot decompose under the conditions prevalent in the North, and threatens to accumulate in the waters of the Arctic Ocean. The development and exploitation of oil fields must be organized in a manner ensuring that oil would not spill into the rivers and would not pollute the surrounding territory. The development of mining involves on-site construction of integrated ore-dressing plants dumping large quantities of waste, including noxious substances. A large number of integrated pulp and paper plants are built in the northern regions. At the present-day level of technological development, these plants discharge harmful liquid and solid wastes. Technology permitting the drastic reduction in waste and residues must be developed as soon as possible.

Industrial development is taking place in the North on a steadily increasing scale. It is therefore reasonable to suggest that the "enterprises of the future" based on a waste-free technology should be built first of all in the North, where ecosystems are weaker and, once disturbed, may never recover.

The effect on the environment of constructing engineering facilities and operating machinery and equipment must be taken into account. This applies to all sectors of the economy, but is particularly vital with respect to transportation, mining, construction and some other sectors. For example, the use of certain types of tracked vehicles in the North leads to serious damage of the vegetal and sod cover. Conventional methods of highway and oil or gas pipeline construction used in the central zone prove unacceptable for the regions affected by permafrost, since they cause deformation of the surface and other damage. Recovery from disturbances to nature is a much longer process in the North than in other regions. When new machinery and equipment are designed, appropriate provisions must be made to exclude or reduce significantly their harmful effect on nature.

One of the important ways of doing this is to integrate the use of natural resources, making it possible to avoid various kinds of industrial waste. The methods used for determining economic efficiency must be supplemented with new elements and standards reflecting the effect of technology on the natural environment.

Let us discuss briefly the concepts of the Near and Far North, as well as the trends in the development of resources in these two subzones, in order to define the environmental protection measures arising from their respective needs.

In economic terms the Northern Zone comprises the territories of the U.S.S.R. located north of the established regions of the country and are characterized by harsher natural conditions with limited opportunities for agricultural development and are sparsely populated and poorly developed in terms of industry and transport. In the Asian North,* seasonal water transport is the only mode of transportation in the summer, and winter roads in winter.

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* Referred to also as the Siberian North. (Transl. Ed.)

The territory examined is earmarked for economic development because of its giant reserves of natural resources needed for developing the economy of the U.S.S.R. as a whole. The southern boundary of the Northern Zone has been defined as proceeding from specific geography and economic conditions in the territories covered by this designation: a harsh environment - long cold winters, strong wind, extensive permafrost, large marshy areas. These conditions are unfavourable for agriculture and cause considerable difficulty for the development of industry and for highway construction. The territories having the harshest climate are unfavourable for settlement. The territories included in the Northern Zone on the basis of these characteristics are the Murmansk and Arkhangel'sk oblasts, the Komi and Karelian A.S.S.R. (in the European North), the Khanty-Mansiiskii and Yamalo-Nenetskii national okrugs located rather far to the north of the Trans-Siberian railroad line, the northern regions of the Tomsk, Chita, Amur, Sakhalin oblasts, Krasnoyarsk and Khabarovsk krais, Buryat A.S.S.R., Yakutian A.S.S.R., Magadan and Kamchatka oblasts (in the Asian North).

The cost of all the work carried out under northern conditions is considerably higher than that in the more southerly situated economic regions of the country. The higher cost is due to a variety of factors. As a rule, the effect of high cost factors is less marked in territories located near railroad lines and industrial centres than in territories far removed from such development bases and consumer regions.

Proceeding from the above, the territory of the North can be divided into two subzones: the Near and the Far North. The concepts of the "near" and "far" are obviously relative, dependent to a significant degree upon transportation facilities in a given locality. For example, a Northern region that is not connected with the railroad network, but is located at a distance of some 500 - 700 km from the economic territories situated farther south, must be referred to as the Far North, since the cost of transportation required to overcome that distance in the absence of roads is very high. As a result, the work involved in developing this region is much more expensive. On the other hand, a region located at a distance of 1,000 km or more from economically developed territories but linked with them by a railroad line, can be quite justifiably referred to as the Near North, since the transportation factor will increase the cost

of works only negligibly. This will in its turn reduce the effect of other high cost factors.

The territories situated in the relative proximity of a railroad system and of large industrial centres which may serve as bases for extensive development of the natural resources of the North and where climatic conditions are less severe than in the high latitudes, are referred to as the Near North. These territories lend themselves to a larger variety of enterprises, including a local food-production base that would supply livestock products, vegetables, and potatoes.

Since the economic and geographic position of a given territory may alter as a result of transport construction, the boundary of the Near North (for example, in the Asian North) will gradually move northward. For the northern boundary of the Near North there is, however, a limit. It is determined by the specific aspects of environment in high-latitude regions.

Even in the distant future, when a railroad network is built in the Asian North similar to that already operating in the European North, the Far North will include the tundra and treed-tundra zones, as well as parts of the taiga zone located in high latitudes and characterized by the harshest environmental conditions, particularly difficult for human acclimatization. According to the terminology used in physical geography, the Far North will include in the future the Arctic and Subarctic territories, i.e., one fifth of the territory of the U.S.S.R. At the present time the Far North embraces a considerably larger territory, particularly in the Asian North, where there are virtually no railroads.

As will be demonstrated below, these two subzones of the North differ significantly in environmental conditions, population density, and prospects for economic development. Furthermore, the farther north, the more vulnerable is nature. Let us review some data on the prospects of industrial development in the Far and Near North.

The Far North encompasses arctic deserts, tundras, artic highlands, treed tundras and, partly, the northern taiga. It is characterized by the harshest environment and unstable ecological systems. The renewal of the vegetal cover

is a very slow process - it takes many decades.

The Near North is more favourable for life. It is characterized by the northern and central taiga, even by the taiga of the southern type representing a relatively complex ecological formation. However, even in this zone nature can be easily damaged and the process of recovery is slow. Biological productivity is lower because the belt located farther south is enriched by various forest-steppe species, while the North has no migrants from other ecological zones. Inefficient forest management impoverishes these regions biologically as well as economically.

It should also be kept in mind that self-purification of water proceeds very slowly under northern conditions. While in the central belt organic pollution disappears a few hundred kilometers down the river course, in the North rivers experience little purification while transporting their water over immense distances (over a thousand kilometers) across territories where aquatic ecosystems become progressively simpler and cannot serve as filters.

The native population of the North is engaged mainly in traditional occupations pursued over the ages: reindeer breeding, hunting, fishing; and on the coast, hunting for sea mammals. This type of economy prevails over immense territories, where the population has developed traditional practices that ensure a minimum harmful effect on nature. During recent decades, however, industry has been vigorously developing in this area and in the future there will be industrial regions covering significant territories.

At the present time the largest industrial enterprises developed in the Far North are in the Murmansk Oblast, chiefly in its central part crossed by an electrified railway, and in Murmansk proper, which is the largest port and city in the North with a population of 329,000.* The total population density in the district is 5.8 per km^2, i.e., the highest density in the northern zone. The discovery of giant high-grade apatite-nepheline ore deposits in this area

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* "Narodnoe khozyaistvo SSSR. 1922-1972 gg." ("National economy of the U.S.S.R. 1922-1972"). Moscow, izd-vo "Statistika", 1972.

has contributed to the industrial development of the region situated beyong the Arctic Circle. The apatite concentrate, yielding four fifths of the cheapest phosphate raw material for fertilizers in the U.S.S.R., has been produced for decades from these ores. Nonferrous metallurgy, mining for mica and iron ore are being developed in this region and a large fishing centre (yielding one sixth of the total catch in the U.S.S.R.) has been created here. A considerable portion of the output (the apatite concentrate and iron ore) is exported to different countries.

This region has considerable potential for further development: the total utilization of nephelines, a portion of which continues to be dumped at present, and a significant development of secondary industries. Hydropower resources of the many rivers in this region will be developed, since the lack of a local fuel base inhibits the economic development of this territory. A large nuclear power station is under construction.

Farther east there is scarcely any industry in the Far North of the European U.S.S.R., excepting the Pechora coal basin, where the output of coal has reached approximately 20,000,000 tons. Coal mining will develop in the future mainly because of the abundance of coking coals that can be transported very economically as far as the central regions of the country and to the Urals.

However, the future of the European Far North in the U.S.S.R. is associated with the large oil and gas fields discovered in the Timan-Pechora oil and gas province. It has been suggested that a port be built in Indiga Bay and that it be linked by rail with an Ukhta - Indiga line. This would speed up development in the northern part of the province not only of the oil and gas, but of many other industries, such as the forest industry in the zone near the railroad, mining for bauxite, construction materials industry, and a number of others. The Timan-Pechora industrial complex is shaping up in this area.

In the Asian part of the U.S.S.R. the Far North subzone is where the main fuel source in the Union is being developed on the basis of natural gas. Immense natural gas reserves, amounting to more than half the total reserves in the U.S.S.R., occur in the north of Tyumen Oblast. This is one of the largest occurrences in the world. Gas pipelines are under construction

from the Urengoi and Medvezh'e fields to the Urals (the virst went on stream in 1973) and to central regions of the European U.S.S.R. A portion of the gas will be exported from here to European countries and to the United States of America.

A large nonferrous metallurgy centre is developing in the Taimyr National Okrug in the region of Noril'sk. Moreover, the entire territory of the Okrug holds promise for industrial development, since there are grounds for believing that various valuable minerals may be discovered in this region. Farther east there extends a broad belt of metallogeny, where occurrences of tin (Deputatskoe) on the Yana, of gold, tin, mercury and other valuable minerals in the Chukchi National Okrug have already been discovered.

Thus, despite the harsh environmental conditions, industrial development is proceeding in the Far North at full speed wherever the natural resources make it economically justifiable, and wherever those resources are needed by the national economy of the country.

The rate of industrial development in the regions of the Near North is much greater. In the European North these include the major portion of the Arkhangel'sk Oblast, and the Karelian and Komi A.S.S.R. The industries developed on this territory are logging and wood-processing industries yielding over 10% of the total pulp and paper output in the U.S.S.R., oil and gas in the Komi A.S.S.R. a fairly well-developed machine-building industry in the Karelian A.S.S.R., and in the Arkhangel'sk Oblast, manufacturing machines for the forest-based industry, shipbuilding and repairs. Up to half the total industrial output of the European North comes from processing industries.

Development of the largest base for the oil industry in the country is underway in the Near North of Western Siberia, in the middle course of the Ob river. Moreover, the oil industry may be expected to move farther north. A large-scale logging and forest-products industry is also developing here. A large complex of enterprises and a key railroad system are under construction. This will open wide prospects for developing the major West Siberian economic complex in accordance with resolutions of the XXIII and XXIV Congresses of the Communist Party of the U.S.S.R.

In the Yenisei North we should note the development of the forest industry in the lower Angara basin, the large Bratsk-Ilimsk industrial region based on cheap power supplied by the immense Bratsk and, eventually, Ust'-Ilimsk hydropower stations (aluminum production, forest products complexes, etc). The construction of a cascade of large hydropower stations is anticipated on the Middle and Lower Yenisei and on the lower course of the Angara River. The natural resources, as yet inadequately explored, in adjacent territories give us grounds for anticipating the construction of a number of industrial centres, as well as of a railroad along the right bank of the Yenisei River. The latter will link Noril'sk with the national railroad system and will further the development of the adjacent area on the right bank, which is rich in natural resources.

The Aldan mining region is developing in the Yakutian A.S.S.R. In the next seven or eight years it will be serviced by a rail line that will extend north of the Amur railroad and will contribute to the development of a large-scale coal industry intended to supply the Far-Eastern ferrous metallurgical industry. Iron-ore mining and the already existing gold and mica industries will be developed. It has been suggested that the natural gas fields in the Lena trough (with forecast reserves of 13 trillion m^3) be intensively developed in order to supply gas to the southern part of the Far East, where a portion of the gas will be liquefied and exported through the Far-Eastern ports to Japan, the U.S.A.,and other countries.

Development of the Udokan deposit, the largest copper discovery in the U.S.S.R., is scheduled for the north of the Chita Oblast.

The projected construction of the North Siberian and Baikal-Amur railroads, i.e., of the trunk lines which will cross the whole Near North in the latitudinal direction, will provide a base for extensive development of natural resources over an immense territory, from which further advances to the North will be launched.

In the long term, the entire northern zone, both the Near and the Far North, will be involved in the process of industrial development. Our task is to apply achievements of science and technology in order to anticipate the consequences of our interference with the natural environment, keeping in

mind its instability and vulnerability. The authors of the articles on ecology published in the present issue aimed at ensuring the necessary measures for preventing hazards to the environment. This issue is essentially the first attempt at analyzing the problems involved in environmental protection under specific northern conditions.

The effect on the environment of developing the natural resources of the North, and the measures to be taken for protecting the environment, are thoroughly elucidated in this issue. The first section deals precisely with these problems.

Regional problems pertaining to different parts of the North are examined in the second section. An attempt to relate urban development in the North to the environment is made in the third section. The problem examined in the third section has so far been inadequately studied and the articles presented here include a number of debatable points. They do raise, however, the most urgent questions in that field. The fourth section reviews foreign experience and the organization of environmental management in different countries from the viewpoint of the scientists and specialists working in that field.

The section entitled "Communications" comprises short articles dealing with diverse topical problems related to the development of the North.

This issue offered to the reader is the first attempt at elucidating ecological problems under northern industrial-development conditions in accordance with the resolutions of the September (1972) session of the Supreme Soviet of the U.S.S.R. and with the Decree of the Central Committee of the Communist Party of the Soviet Union and of the Council of Ministers of the U.S.S.R. in 1973.

A great deal of comprehensive research will be needed in order to find proper solutions for the problems examined. The papers included in this issue reflect to a certain extent the amount of information currently available on these problems, both in our country and abroad.

This issue is intended for large circles of readers interested in the future of the Soviet North.

RESOLUTION OF THE SUPREME SOVIET OF THE U.S.S.R. CONCERNING MEASURES FOR THE FURTHER IMPROVEMENT OF ENVIRONMENTAL PROTECTION AND THE RATIONAL USE OF NATURAL RESOURCES

Whereas the protection of the environment and the rational use of natural resources have become a major nationwide concern of our state owing to the rapid development of industry, transport, and agriculture, along with the expansion of the scientific and technological revolution, and the all-round growth in material and cultural demands of the Soviet people;

And whereas our method of dealing with environmental problems will affect the successful fulfilment of national economic plans and the welfare of present and future generations, and the solution of environmental problems in a socialist state is inextricably bound up with both public health protection and providing the Soviet people with the necessary prerequisites for fruitful labour and rest;

And whereas the national ownership of land, mineral resources, water and forests constitutes in the Soviet Union the secure basis for properly organizing both the use of natural resources and effective environmental protection, since these are precisely the conditions under which planned management of the economy and a high rate of economic development can be assured;

And whereas the efficient exploitation, conservation and renewal of natural resources and careful environmental management are basic constituents of the programme for building communism in the U.S.S.R., and the Communist Party and the Soviet State display indefatigable concern for environmental protection and the rational use of natural resources;

And whereas the XXIV Congress of the C.P.S.U. mapped out important measures for strengthening environmental protection in our country and increasing the responsibility of different ministries, agencies, enterprises, institutions

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Problemy Severa, (18): 11 - 14, 1973.

and organizations for the rational use of natural resources, as reflected in the 1971-1975 five-year plan for the national economic development of the U.S.S.R.;

And whereas the Fundamentals of Agrarian Legislation of the U.S.S.R. and the Union Republics, Fundamentals of Water Legislation of the U.S.S.R. and the Union Republics, Fundamentals of the Health and Welfare Legislation of the U.S.S.R. and the Union Republics, as well as corresponding laws and codes of the Union Republics adopted in recent years, are highly important for solving problems related to improving environmental protection and the rational use of natural resources in our native land;

And whereas in bringing environmental protection plans into realization the Soviet Union is steadily expanding its cooperation in this field with foreign states and international organizations, and is ensuring the fulfilment of its obligations;

And whereas the Supreme Soviet of the U.S.S.R. notes that measures aimed at improving environmental protection and ensuring the rational use of natural resources are implemented consistently in the Soviet Union;

And whereas extensive measures have been undertaken in land development and the prevention of wind and water soil erosion, the exploitation of water, forest and mineral resources is being improved, valuable or rare animal species have been placed under state protection, management of the fishing industry has been improved, measures designed for controlling air and water pollution, improving the organization of the supply of heating and gas to cities and other populated centres and controlling noise pollution are given close attention, and capital investments in environmental protection measures and in the construction of sewage, smoke, and dust filtering plants have increased significantly;

And whereas the further development of the national economy and the growing use of natural resources demand increased concern by all national and public organizations for environmental protection and improved natural resource management, as well as for eliminating serious shortcomings in that area;

And whereas certain ministries, agencies, local councils of workers' deputies, enterprises and organizations have thus far failed to take these requirements fully into account and to deal appropriately with ensuring the rational use of natural resources and environmental protection;

And whereas various ministries, agencies, enterprises and organizations have failed to carry out in full the legislation pertaining to the comprehensive use of mineral resources, permitting great losses of useful minerals during their recovery and processing by the extraction of only the basic metals, while significant amounts of associated components are disposed of, resulting in a loss to the state;

And whereas technological processes making possible a marked reduction in the consumption of industrial water and in the amounts of hazardous waste having a detrimental effect on the environment are slow in being developed and implemented in industry, many enterprises and a number of cities and towns lack the necessary facilities for sewage treatment because they procrastinate in building such installations and fail to make full use of funds appropriated for that purpose, industrial discharges into the atmosphere are not filtered in the proper manner, and antipollution devices for smog and dust control are manufactured in inadequately small quantities;

And whereas in the solution of urban development problems and in developing rural areas insufficient attention is often paid to creating optimum working, living and leisure conditions for the population;

And whereas, the basic national resource, i.e., land, has been badly managed, agricultural or forest lands have been inefficiently used, and water reservoirs have been improperly exploited, and large areas of fertile land are often lost because of mining, construction, and soil erosion or salination;

And whereas neither the Councils of Ministers of union republics, nor the ministries and agencies of the U.S.S.R. entrusted with the national supervision and control over the enforcement of environmental protection and

natural resource use legislation pay due attention to discharging the responsibilities vested in them in that field, and local Councils of workers' deputies have thus far failed to display due concern for rational land management and for efficient utilization of agricultural land, forests and water, and they have likewise failed to exercise adequate control in order to ensure implementation of measures aimed at improving soil fertility and protecting the animal and plant kingdoms;

And whereas scientific research organizations have failed to respond to appeals for their participation in solving urgent problems related to the integrated use of natural resources and the protection of the environment;

And whereas the Supreme Soviet stresses that under the socialist economic system the achievements of the scientific and technological revolution in conjunction with our powerful industrial base make it possible to exploit effectively all natural resources and to resolve successfully the historically vital problem of neutralizing the side-effects of economic activities hazardous to man and the environment;

And whereas the measures capable of ensuring the effective protection of the environment include the integrated use of natural resources, the implementation of waste-free technological processes, more extensive use of biological means of purifying water basins and for pest control in agriculture, reforestation and land improvement programmes;

And whereas further programmes for developing the economy of the Soviet Union as a whole, and of its different sectors in particular, must therefore be realized on the basis of integrated in-depth research, and should be accompanied by scientific forecasts of possible consequences as well as by a mandatory system of measures precluding harmful effects on the environment;

And whereas it is our duty to conserve and multiply all the riches and beauty of nature for the future generations who will live in a Communist Society;

The Supreme Soviet of the Union of Soviet Socialist Republics

resolves:

1. To consider that one of the paramount national concerns is continuous concern for the protection of the environment and the improved use of natural resources and for the strict observance of the legislation designed to protect the land, mineral resources, the forests, water, the animal and plant kingdoms and the air within our atmosphere,keeping in mind that scientific and technological progress must be realized in conjunction with the careful management of nature and its resources, and must contribute to the creation of the most favourable conditions for the life, health, work and leisure of the workers.

2. To entrust the Council of Ministers of the U.S.S.R. with the development of measures for further intensifying environmental protection and for improving the use of natural resources, keeping in mind (a) the suggestions made by the deputies of the Supreme Soviet of the U.S.S.R. during the session, (b) the proposals of the commission responsible for environmental protection, and (c) proposals of the other permanent commissions of the Soviet of the Union and Soviet of Nationalities of the Supreme Soviet of the U.S.S.R.

To provide in these measures for:

Improved planning for the rational use of natural resources and environmental protection, keeping in mind that the preventive measures mapped out must be a constituent part of the projected and annual plans for the development of our national economy;

Increased responsibility of the various ministries, agencies, enterprises and organizations (a) for the full, integrated utilization of useful minerals and mineral raw material during their recovery and processing, (b) for the strict observance of the legislation aimed at a truly efficient management and conservation of land, forest and water resources, including increased responsibility of each citizen for environmental conservation;

Increased responsibility of the various ministries, agencies, enterprises and organizations for implementing measures designed to prevent (a) the pollution of soils from industrial waste and toxic chemicals, (b) the

contamination of water sources from industrial waste and municipal sewage, and (c) the contamination of air from industrial discharges and exhaust gases from automotive transport and also the unconditional observance of public health standards and rules;

Implementation of necessary measures (a) for preventing the discharge of hazardous waste into the atmosphere, (b) for preventing the dumping of raw sewage, (c) for the timely construction of purification plants, (d) for improving the quality of antipollution installations by developing and introducing new types of filtering equipment and devices for smoke and dust, (e) for ensuring the biological decontamination of water basins, (f) for developing new and improving the existing technological production processes, and (g) for the economical consumption of water;

Increased manufacturing of machinery, equipment, control and monitoring devices and automated means for improving the organization of environmental protection, and to make more effective use of natural resources and wealth of the country;

Preparation of urban development standards ensuring the maximum improvement of environmental health in industrial and administrative centres;

Increased research related to the major problems of environmental protection and the rational use of natural resources;

Improved teaching of natural sciences and environmental protection in primary and secondary schools, and in special and higher institutions of learning, and expanded output of highly qualified specialists in this field to mobilize the enormous natural resources skillfully and efficiently;

Active participation of the U.S.S.R. in the development and implementation of international cooperation programmes in the field of environmental studies and protection;

3. That the Councils of Ministers of the union republics, appropriate ministries and agencies will ensure strict supervision and control guaranteeing the proper use of natural resources and protection of the environment.

That local Councils of workers' deputies will strengthen their control over the implementation of measures for the rational management of agricultural land, forests and water, for protecting the animal and plant kingdoms, for improving sanitation in the cities and other populated centres, and for controlling industrial and conventional types of noise pollution.

4. That permanent commissions of the Soviets of the Union and of Nationalities will take into account the suggestions and comments voiced during the session, when drafting the Fundamentals of Forest Legislation for the U.S.S.R. and for the Union Republics and Fundamentals of Mineral Resources Legislation of the U.S.S.R., and of the Union Republics.

N. Podgornyi
Chairman of the Presidium of the
Supreme Soviet of the U.S.S.R.

M. Georgadze
Secretary of the Presidium of the
Supreme Soviet of the U.S.S.R.

Moscow, Kremlin, September 20, 1972

THE CENTRAL COMMITTEE OF THE C.P.S.U. AND THE COUNCIL OF MINISTERS OF THE U.S.S.R.

ON INTENSIFYING ENVIRONMENTAL PROTECTION AND IMPROVING THE USE OF NATURAL RESOURCES

In September 1972 at the fourth session of the eighth convocation, the Supreme Soviet of the U.S.S.R. examined the measures to be taken for the further improvement of environmental protection and the rational use of natural resources, and recognized that one of the major concerns of the State was a continuous solicitude for the protection of the environment and a more effective utilization of natural resources for the purpose of creating conditions of life and health, work and leisure as favourable as possible for the working people.

The Central Committee of the C.P.S.U. and the Council of Ministers of the U.S.S.R. have adopted the expanded resolution concerning intensified environmental protection and improved use of natural resources, in which the suggestions made during that session by the deputies of the Supreme Soviet of the U.S.S.R. have also been taken into account.

Resolutions of the Central Committee of the C.P.S.U. and of the Council of Ministers of the U.S.S.R. note that measures aimed at improving environmental protection and ensuring the rational use of natural resources are being implemented in our country.

It has been noted also that a number of ministries, agencies, enterprises and research organizations have so far failed to come to grips with protecting the environment against pollution and ensuring the rational use of natural resources; nor have they paid adequate attention to the development of technological processes that would eliminate or substantially reduce the pollution of soil, atmosphere and run-off water; nor have they taken

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Problemy Severa, (18): 15 - 18, 1973.

steps to conduct research for improving the methods and technology of sewage and smoke treatment or for other topical problems of environmental protection and the renewal of natural resources.

The Central Committee of the C.P.S.U. and the Council of Ministers of the U.S.S.R. have suggested that the Central Committees of the C.P. and the Councils of Ministers of the union republics,the krai and oblast C.P. committees, the Councils of Ministers of the autonomous republics, the krai and oblast executive committees, the ministries and agencies of the U.S.S.R. (a) focus closer attention on environmental protection and on ensuring the rational use of natural resources; (b) establish the systematic supervision of soil erosion control works and works necessary for the proper management of land, water, forest, mineral and other natural resources by collective farms, various enterprises and organizations; (c) monitor their observance of the existing regulations and standards pertaining to the reclamation of land, prevention of soil pollution or salinization, surface and underground water contamination; (d) undertake measures for the conservation and renewal of the animal and plant kingdoms, and the prevention of atmospheric pollution.

The functions of ministries and agencies in the field of environmental protection and rational resource use are defined precisely in the resolution; in particular, it has been resolved that:

The Ministry of Reclamation and Water Resources Management of the U.S.S.R. effects state control over the rational use of water resources and implements measures aimed at protecting bodies of water against contamination, pollution or depletion and controls purification facilities and sewage disposal;

The Ministry of Agriculture of the U.S.S.R. controls the observance of land legislation and land management practices, and is responsible for (a) organizing the proper use of toxic chemicals in agriculture; and (b) developing and extensively applying biological means of controlling diseases and pests of agricultural crops and plantings;

The Forest Resources Management State Committee of the U.S.S.R.

Council of Ministers exercises state control by ensuring the rational use of forest resources in the country. It is responsible for (a) the regeneration, renewal and increased productivity of forests, (b) organizing forest-fire control, extinguishing fires, and protecting forests against harmful pests and diseases, and (c) safeguarding forests against illegal felling and other detrimental actions;

The Ministry of Fisheries of the U.S.S.R. ensures the protection, reproduction and replacement of fish stock, the control of fishing, as well as protection of the natural wealth on the continental shelf of the country;

The State Committee for Safe Practices in Industry and Mining of the Council of Ministers of the U.S.S.R. controls the conservation of mineral resources and proper exploitation of mineral deposits.

The responsibility for the pollution control of atmospheric air in the cities and other populated centres lies with the Councils of Ministers of the union and autonomous republics, oblast executive committees, and krai and municipal executive committees. They are also obliged to strengthen control in order to ensure that all the enterprises and organizations, whatever their ministerial affiliation, take measures to protect the environment and to improve the use of natural resources, as well as to ensure the strict observance of the established regulations for protecting the natural environment by all citizens.

The resolution provides for measures aimed at (a) improving the planning and reporting in the field of environmental protection and use of natural resources; (b) improving the design of industrial enterprises and urban planning; and (c) organizing a nation-wide service responsible for monitoring and controlling atmospheric, soil and water pollution levels. In particular it has been resolved that beginning in 1974, projected and annual plans must be worked out for the rational use of natural resources and for environmental protection as a constituent part of the projected and annual plans for the economic development.

It has been suggested that the main administration of the hydrometeorological service affiliated with the Council of Ministers of the U.S.S.R.

organize a nation-wide service for monitoring and controlling the level of pollution in the atmosphere, soil, and water.

The State Committee for Science and Technology of the U.S.S.R. Council of Ministers has been requested (a) to develop, in cooperation with corresponding ministries and agencies, research projects dealing with the rational use of natural resources and with environmental protection, and to put them into effect; (b) to coordinate the activities of scientific institutions in working out major problems in this area; (c) to ensure financing of the major research provided for in these plans; and finally (d) to ensure that the research is carried out.

The State Committee for Science and Technology of the Council of Ministers of the U.S.S.R. and the Academy of Sciences of the U.S.S.R. have been requested to organize jointly an interdepartmental scientific and technological council affiliated with the Committee, for dealing with the complex problems of protecting the natural environment and making rational use of natural resources.

The Councils of Ministers of the union republics together with the Ministry of Reclamation and Water Resource Management of the U.S.S.R., the Health and Welfare Ministry of the U.S.S.R., the Ministry of Fisheries of the U.S.S.R. and other ministries and agencies concerned, are obliged to develop measures ensuring that dumping of untreated or inadequately treated and decontaminated sewage into water basins cease completely; this applies primarily to the river basins where high levels of water pollution have been recorded or where a strained water balance is anticipated.

The resolution also provides for measures aimed at the large-scale breeding of phytophagous fish in water bodies. The fish would improve the biological clean-up of the water basins from the algae and other plants that are harmful to water resources, and would simultaneously consume large quantities of the biologically active substances accumulating in water reservoirs.

The ministries and agencies of the U.S.S.R. and the Councils of Ministers of union republics have been assigned specific tasks related to designing, and organizing the production and manufacturing of (a) new types of equipment

and devices for sewage treatment plants in cities and industrial enterprises, and (b) instruments for quality control of natural surface water and sewage, as well as tasks related to the development and implementation (1973-1975) of new methods for sewage treatment.

It has been recognized that the Ministry of Chemical and Oil Industrial Engineering should have a main administration responsible for developing and manufacturing smoke and dust filtering equipment, including a subordinate state inspection service responsible for controlling the operation of the anti-pollution installations.

The Councils of Ministers of union republics and the ministries and agencies of the U.S.S.R. have been asked to implement in 1973-1975, measures designed to reduce the toxicity of exhaust gases from vehicle engines in operation and to bring it down to established standards; in particular, to organize the necessary system of control and regulation centres in large cities and resort areas.

In order to reduce the losses of useful minerals during their recovery and processing, as well as to prevent the pollution of the environment by industrial wastes, the Ministry of Nonferrous Metallurgy of the U.S.S.R., the Ministry of Ferrous Metallurgy of the U.S.S.R. and other ministries extracting and processing useful minerals, must endorse throughout their subordinate enterprises (a) plans to implement more effective methods and systems for developing mineral deposits, and (b) technological processes for treating mineral raw materials, which would ensure the most expedient extraction of useful minerals and utilization of the associated industrially valuable components.

For the purpose of improving the state of public health in cities, suburban zones, workers' settlements and rural populated centres it has been suggested that the Councils of Ministers of the union republics:

(a) Ensure that works necessary for expanding green areas in cities and suburban zones be carried out in 1973-1980 (creation of new parks, gardens, boulevards, protective green zones and forest parks, particularly on reclaimed lands);

(b) Ensure that in 1973-1974 the necessary measures be implemented for bringing the unsightly household-garbage dumps located near cities, industrial centres and resort zones, under the control of the state in conformity with the sanitation regulations approved by the Ministry of Health and Welfare of the U.S.S.R.;

(c) Organize the development of design documentation for the construction of plants for processing and burning garbage, and ensure construction of such plants in large cities and resort areas beginning in 1974;

(d) Develop and realize in 1973-1975 measures for organizing the centralized collection, disposal and decontamination of industrial waste in large cities and industrial centres, involving in the implementation of these measures the enterprises under their respective ministries and agencies of the U.S.S.R.

The Central Committee of the C.P.S.U. and the Council of Ministers of the U.S.S.R. have recognized the necessity of increasing the flow of information concerning environmental protection and explaining the importance of the rational use of natural resources.

Ministries and agencies responsible for institutions of learning have been requested to focus closer attention on the teaching of the fundamentals of natural history, rational use of natural resources, and protection of the natural environment.

"Pravda", January 10, 1973

I. THE INFLUENCE OF ECONOMIC DEVELOPMENT ON THE NATURAL ENVIRONMENT OF THE NORTH

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NATURE CONSERVATION IN THE NORTH: AN INTERNATIONAL PROBLEM

The specific features of the problem of nature conservation in the North are determined by the characteristics of the ecological systems in high latitudes, i.e., the thinness of the biologically active "layer", the generally low level of biological productivity, with the exception of specific areas, the slowness of the biological cycle and renewal processes, the sharp seasonal nature and instability of the "functioning" of the ecological systems over the years, depending on the state of the underlying permafrost layer, and also by the specific features of economic activity in the North, i.e., the almost complete absence of agriculture and forestry in high latitudes, the preferential development of the extractive industries and of extensive sectors of wildlife utilization (reindeer husbandry, hunting and fishing), the predominance of seasonal forms of transportation (marine, inland waterways and winter roads, cross-country vehicles, and aircraft for passenger transport), and the high percentage of people who have come to the North from other parts of the country to work temporarily in industry.

There are practically no agrocoenoses or artificial forest plantings in the North. Anthropogenic (i.e., wholly man-made) ecosystems occupy a comparatively small area, and these are mainly inhabited localities, transportation installations and mine workings. The effect of industrial activity on natural ecosystems, which occupy practically the whole of the North, has increased rapidly in recent years.

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Since the territories are used for industrial activities, certain disturbances of the natural environment are unavoidable. The problem is to avoid unnecessary disturbances, especially those which result in irreversible degradation of the natural surroundings. The possible effects of various economic activities on the natural environment of the North, and on the resources for other sectors, must be studied on a first-priority basis so that the necessary decisions and recommendations can be adopted in time.

The prevention of environmental pollution. Pollution problems are of a global nature, and we shall restrict ourselves to a discussion of those aspects of them which are specific for the North.

It is common knowledge that throughout the entire world the persistent biocides used in agriculture and for other purposes are accumulating in the environment, disturbing the biological balance, and resulting in unfavourable consequences for man, who ingests these substances with his food. The only purposes for which biocides are used in the North are the anti-warble fly treatment of domestic reindeer and the experimental treatment of small areas of tundra for protection against bloodsucking insects. One cannot exclude the possibility that in the future areas in oil- and gas-producing regions will be treated with chloro-organic insecticides to combat insect pests. The possible consequences of such measures have not yet been studied in detail, but we can anticipate adverse effects on the environment. It would be better to improve the means of individual protection.

The consequences of the use of biocides are very serious in the North. It has been established that the main dispersal medium of chloro-organic compounds, for example, is not surface runoff, but the atmosphere[11]; therefore they can spread to any part of the world with comparative ease. Compounds of the DDT group and polychlorinated biphenyls are found in the majority of salt-water fish[11], in polar bears[5] and other predators, thus indicating their occurrence in all the trophic levels of ecosystems. The development of certain groups of plankton in northern seas (the minute crayfish *Calanoidea*) is blocked by a DDT content of 10 parts per trillion*, and such concentrations actually

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* 10^{12} (The same applies for American and French systems, while in the British and German systems a trillion is 10^{18}). (Transl.)

exist already[12]. The rate at which these toxins decompose and disperse has not been studied yet, but it is expected that in cold northern waters it will be slower and the contamination more persistent than in the south. Eventually the use of persistent biocides will be restricted and, possibly, discontinued altogether, but even then the gradual absorption of the residues of these substances by water bodies may still lead to an increase in the pollution level. The present tendency to use new nonpersistent biocides instead will probably result in a diminution of their global dispersion; however, the possible influence of these agents and their derivatives on the components of northern ecosystems has yet to be studied.

Atmospheric pollution in and around northern settlements and towns has already reached a high level. The continental subarctic territories, with their cold winters and temperature inversions, are the regions with the highest potential pollution levels. Large quantities of oil and gas are burnt off at well sites, thus polluting the atmosphere over vast areas. Other sources of air pollution are increasingly frequent forest and tundra fires, transport operations, etc. It is a well known fact that polluted air masses can travel very great distances. Thus, air masses containing large quantities of sulphur dioxide are carried from Britain to Scandinavia. These have so changed the pH of certain rivers that salmon fry have ceased to develop in them[7]. Lichens are extremely sensitive to atmospheric pollution (especially SO_2) because of their nutrient intake characteristics. It has been demonstrated that air pollution resulting from the combustion of oil and gas inhibits the growth of lichens[1], which, in turn, reduces the food productivity of the territory for wild and domestic reindeer, since lichen is one of their principal foods. In the opinion of some scientists, the development of the oil industry in the American North may even lead to the complete disappearance of lichens in large areas[15]. Norway, Sweden and Finland, as well as Canada, are studying the influence of pollution on the growth of lichen within the framework of the International Biological Program.

In the long term the level of atmospheric pollution (primarily domestic and industrial, caused by the inefficient combustion of oil and gas and by

forest fires)* will have to be reduced. The elimination of the consequences of present day pollution alone (for example, the restoration of the lichen cover) may take a long time, because of the slow growth of lichens.

Radioactive waste which gets into the atmosphere also has a tendency to accumulate primarily in lichens and then, further along in the food chain, in the tissues of reindeer. In Canada it was found that in the 1950s the content of radioactive isotopes in lichens increased 50 times[3]. At the beginning of the following decade wild reindeer meat in Canada and Alaska was found to contain 10 - 20 times more Sr^{90} and 10 - 100 times more Cs^{137}[6], and in Sweden 280 times more Cs^{137}, than the meat of domestic cattle[10]. Four times more Sr^{90} was found in the tissues of Alaskan Eskimos than in inhabitants of the Temperate Zone[16].

The problem of radioactive contamination has probably become less acute in recent years, but little is known of the long-term effects of the radioactive contamination which has already accumulated.

It is anticipated that in the near future there will be a considerable increase in the oil-bearing areas in the North and a sharp increase in oil production. The danger of water bodies becoming contaminated by oil and oil products must be averted. In the American North it is proposed to minimize the danger of oil pipeline leaks by installing valves at one-mile intervals that will automatically shut off the pipe in case of a rupture or a drop in pressure. Pipes of very high tensile strength are being developed[1]. Nevertheless, even with suitable leakage control, accidental oil spills will occur and water bodies and terrestrial ecosystems will be contaminated. It is essential to ensure that leakage is minimal, localized in small sectors, and that the least possible damage is caused. It is also necessary to study the rate of the natural processes of biological decontamination (in particular, the degradation of oil products in nature), which is undoubtedly slower in the North than it is in the South.

Every year more than 2,000,000 tons of oil are released into the

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* Alaskan state law forbids the burning of casing-head gas in Prudhoe Bay. The gas must be transported to the south, through a pipeline following the route of the oil pipeline and using the same right of way, in order to minimize damage to the natural environment. Power lines and service roads must also lie within this corridor.

sea[11]. We are all too familiar with the biological catastrophes caused by tanker accidents in which large quantities of oil are spilled into coastal waters. But the biological effects of "chronic" oil contamination (caused, for example, by the release of ballast water from tankers and shore maintenance facilities, defects in oil installations, etc.) have hardly been studied at all, despite the fact that such pollution results in the poisoning of certain sea animals (including commercially valuable fish), impoverishment of ecosystems, and degradation of the ecological and recreational qualities of the environment. Large doses of biocides can be dissolved and concentrated by oil slicks.

Oil contamination may be particularly persistent in northern seas, since microbiological degradation of the oil is inhibited by the low water temperatures, ice hinders the dispersal of the oil and it accumulates in the coastal belt. It is a particular hazard to aquatic birds, a biological resource used both in the Arctic and elsewhere (during migration and wintering), while in delta areas it endangers the feeding grounds of valuable fish. Eventually the arctic seas may be contaminated by much larger quantities of oil as shipping increases and especially as a result of spills occurring during oil recovery operations on the sea shelf (off-shore drilling is planned in Alaska in Prince William Sound, Bristol and Izembek bays[18] and, possibly, on Spitsbergen).

Administrative measures for the protection of northern seas from oil pollution have been adopted both at home and abroad. Thus, in 1970 a law was passed forbidding the sale of licences for the extraction of mineral resources, oil and gas in the interior of Bristol Bay, a centre of the salmon fishing industry. However, the effect of this law was later suspended[18]. Nevertheless, the U.S. Department of the Interior and the Alaskan Department of Natural Resources announced that they would not authorize oil exploration and extraction in Izembek and Bristol bays unless guarantees could be given that it would not result in contamination of the natural environment and degradation of the habitats of wild animals.

The U.S.A. and Canada are at present studying the possibility of concluding an international agreement on the prevention of oil pollution in the Arctic[18].

In the future it will be necessary: to study oil dispersal patterns

and degradation rates in northern ecosystems; ascertain the permissible contamination levels for different components of northern ecosystems; develop means of removing oil from ice-covered seas; and to devise measures to prevent oil spills during off-shore oil production under arctic conditions.

Atmospheric and surface-water pollution levels are monitored in all the northern countries. However, more attention should be devoted to studying the effect of pollution on individual components of the natural environment and ecosystems as a whole and devising ways of protecting the ecosystems.

Apart from the above-mentioned problems, which are peculiar to the North, it is necessary to conduct research on the protection of the environment from pollution on a global scale, since this is just as important for the North as it is for any other part of the world.

The protection of individual forms of biological resources. The main industries concerned with the exploitation of biological resources in the Far North are reindeer husbandry, hunting, and fishing. A large amount of literature has been devoted to problems of the study, utilization and protection of these resources. We shall consider only two aspects.

1. The first is the interrelationships between domestic and wild reindeer, the main consumers of tundra vegetation, that provide most of the meat in the area. This problem can be solved by optimizing relationships between reindeer husbandry and the wild reindeer hunting industry. In Scandinavia and Alaska, where the main habitats of wild and domestic reindeer are separated, little attention is paid to this problem, while in Canada attempts to develop reindeer husbandry have been abandoned entirely[17]. In various regions of the Soviet North, which has the largest reindeer population in the world, the prospects of reindeer husbandry vary according to the pasture resources, economic trends, features of the way of life of ethnic groups, etc. It seems to us that optimum relationships between reindeer husbandry and wild reindeer hunting should be worked out separately for different regions of the North in the very near future.

2. The second is the protection of rare species of plants and animals. There are many rare species in the North. A number of administrative

measures for their protection have already been adopted in various countries: the hunting of polar bears (forbidden in the U.S.S.R.), wolves, wolverines, etc. has been restricted, and the harvesting of some species of animals forbidden altogether. However, the progressive development of the North increases the danger of disturbing the habitats of rare species and leads to a reduction of their numbers, even though they are not directly harvested by man. We should now study the distribution and biology of these species and the possible effect of anthropogenic changes in their habitats, and develop ways of conserving them. In particular, it is necessary to determine the areas in which it is considered desirable to limit a particular economic activity for conservation purposes.

The effect of transport on the natural environment. The volume of freight shipments and the quantity of transport equipment in the North increases every year. Certain types of transport cause serious damage to the natural environment and there is a need to introduce preventive measures to minimize this damage or eliminate it altogether. We shall mention some of the problems which arise in this connection.

1. The use of heavy tracked vehicles causes damage to the natural environment, the productivity of ecological systems as a whole and, in particular, reindeer pastures. The tracks of crawler and cross-country vehicles tear up the moss cover, which results in thawing of the permafrost layer, the development of erosion and thermokarsts on roads used by tractors. The biological productivity of the territory and its value as reindeer pasture decreases sharply; and the damage is not repaired for many years.

Research on the prevention of damage to ecosystems by tracked vehicles was started in Canada and Alaska several years ago. The initial recommendations were as follows. Roads should have only a slight gradient. Permanent roads should be constructed with gravel fill 1.2 - 1.5 m in depth on top of the root mat. According to the recommendations of the National Research Council of Canada and the U.S. Army Cold Regions and Engineering Laboratory, gravel is now dumped onto the tundra vegetation on either side of the existing road, in order to make use of the buried vegetation as an insulating layer. The depth of the gravel depends on the permissible load on the substratum and the weight of the

vehicles. The Dempster Highway and roads in the region of Prudhoe Bay were constructed by this method. All work should be carried out only after the soil has frozen[1].

All shipments by heavy tracked vehicles should be made during the winter. Many oil companies in Canada and Alaska adhere to this principle. Enactments passed by the U.S. authorities since 1969 forbid the use of tracked vehicles on thawed tundra, which should in future eliminate the problem[5].

Winter roads should not be used in the early fall or late spring. In the fall the surface is liable to damage during the period when it has already begun to freeze, but thawed patches still remain above the layer of frozen soil. In addition, it is essential to keep to low-lying areas where possible. Sedge communities in low-lying areas recover more rapidly since their underground parts remain alive. Shrubs on high ground suffer more damage, but the construction of winter roads of compacted snow will help to protect even these plants.

Winter road routes, winter drilling sites, landing strips, etc., should be selected in the summer when it is possible to ascertain which places are the least vulnerable to surface damage.

Where possible, vegetation renewal should be stimulated by cultivation methods. For instance, it has been established that there are several species of grass that inhabit old sites of surface damage. These are now being tested in growth chambers in which their natural growth conditions are simulated, and then they will be proved under field conditions[19].

A program was initiated in 1970 to test transport vehicles with tires that exert a low unit ground pressure on Banks Island (Northwest Territories, Canada) and in northern Alaska to ascertain which vehicles and tires are most suitable for travelling across the tundra with the least damage to its surface and vegetation, particularly during geophysical surveys. The effect on the vegetation cover was evaluated by geographers and biologists of the Canadian Wildlife Service. Vehicles with huge cushionlike tires (pneumatic rollers) proved to be the most promising. There is a great future for these in the

transportation of geophysical equipment, drilling rigs, geological teams, supplies, fuel, compressors, etc.[4].

Also recommended are general-purpose ground-effect vehicles, and in the summer, heavy helicopters.

In the oil-bearing regions of Western Siberia we have mastered the art of making permanent roads which freeze to a great depth in winter and are subsequently insulated with fill in order to prevent the frozen soil from thawing. New machines are being produced with wide tires that exert a low unit ground pressure. The anticipated increase in transportation by heavy tracked vehicles in the North calls for a program of special studies to determine the effect of tracked transport on ecological systems and the implementation of the relevant recommendations in the years immediately ahead.

2. Railways, highways, and especially large-diameter surface oil pipelines present formidable obstacles to migrating reindeer. The animals gather at these obstacles for long periods and are unable to forage normally; their biological cycle is upset and their physiological condition deteriorates; they mate and produce their young in unsuitable conditions and regions[8]. The incidence of barrenness increases and calves die. Adults as well as calves perish on the railroad tracks and highways, and at the hands of poachers, who are attracted by such gatherings. The network of railroads and, in particular, highways in the North will be extended in the future and so, of course, will the gas and oil pipelines.

Studies of the behaviour of reindeer, their attitudes to such obstacles, and methods of preventing undesirable consequences have been initiated in the U.S.S.R., the Scandinavian countries, Canada and Alaska[7]. Ways of preventing such damage must be worked out rapidly, so that appropriate recommendations can be included in new road and pipeline projects from the outset.

3. In the construction of main oil pipelines we are faced with the problem of permafrost degradation along the pipeline route resulting from disturbance of the vegetation cover and thawing of the soil, especially if the

oil being piped has a temperature of +65 to 80°C. This could lead to surface erosion, "subsidences" and eventually ruptures in the pipeline and oil spills, especially in earthquake regions. If, however, the pipeline is mounted on piles, the risk of breaks is reduced, but at the expense of interference with the migration routes of wild animals[1,18]. We shall discuss the evaluation of pipeline designs in more detail below.

4. The anticipated long-term intensive development of air transportation in the North, in addition to pollution problems, threatens the existence of wildlife in the region. It has been found that the alarm, caused by low-flying aircraft and helicopters, disturbs the physiological condition of the animals and reduces their productivity[8]. Flights over reindeer herds result in abortions, loss of calves and, in winter, pneumonia in adult animals. In the U.S.A. a special law has been passed forbidding the use of air transport in locations and under conditions in which it disturbs animals; however, the problem has not been studied scientifically, either in the U.S.S.R. or abroad.

The evaluation of large-scale projects from the point of view of their effect on the natural environment. Any large-scale projects, which are submitted, or will be submitted (for example, the construction of a hydroelectric power station, oil and gas pipelines, the diversion of part of the discharge of northern rivers to the south, etc.), should be pre-evaluated from the point of view of their effect on all the components of the natural environment and, in the final analysis, on the biological productivity of ecosystems. For example, the hydroelectric power project on the Yukon River (Alaska) was abandoned because the anticipated damage to the biological resources was too great. Studies are being conducted to determine the possible ecological consequences of a large-scale hydro construction scheme in Central Iceland and small hydroelectric power stations in the mountains of Scandinavia. A comprehensive study should be carried out to determine the potential ecological consequences of the construction of hydroelectric power stations on the lower reaches of the Lena (which could have an adverse effect on the fishing industry, for example), the projected diversion of part of the discharge of the Ob and Irtysh rivers to the south, and future oil and gas pipeline projects. A study is now being carried out to determine the possible effects on the natural environment of the proposed meridian oil

pipeline in Alaska* and the Alaska - Canada - Western U.S.A. oil pipeline along the Mackenzie River Valley. We shall examine this question in greater detail.

The functions of the Subcommittee on Pipeline and Land Use Technology in Northern Terrain, which was set up by the National Research Council of Canada, include the examination of problems which may arise in pipeline construction in the North and associated disturbances of surface structures.

The selection of a pipeline route entails not only an evaluation of the engineering and technical complexity and the economic cost of each project, but the damage that will ensue as a result of disturbing the natural environment.

The Northwest Planning and Research Group is carrying out a vast program of environmental research. It is financed by six oil and gas companies, which have allocated $12 million for engineering and ecological studies of the proposed route of a 48-inch pipeline, extending 2,500 miles from Prudhoe Bay in northern Alaska to the east and south across Canada along the whole of the Mackenzie Valley to the American Middle West.

The aim of botanical research work in this connection is to find acceptable means of restoring the vegetation above a buried pipeline in order to avoid thermal erosion of the underlying permafrost. Zoologists are studying the biology of fish, birds, caribou, and other mammals on the northern shores of Alaska and in the basins of the Mackenzie and Yukon rivers. A series of experiments has been planned to determine what effect the construction and operation of a pipeline might have on the wildlife resources[14].

The Gas Arctic Systems Study Group are carrying out interesting research work in the Northwest Territories, Canada, and Northern Alaska. Here two experimental 48-inch pipelines have been constructed for the purpose of collecting technical information about the construction and operation of pipelines (both buried and laid on tundra and permafrost) and the equipment associated with them in the Arctic. In addition, ecological information will be collected

* Construction was sanctioned by the Alaskan state authorities at the end of 1972.

on the possible influence of pipeline construction on the landscape, as well as the influence of pipeline construction and industrial development in general on the native inhabitants[9].

The firm constructing the Alaska pipeline (ALPS) and the federal government of the U.S.A. are subsidizing research on the problem of renewing the vegetation cover (natural or artifically created) on soil exposed during the contruction of the pipeline in order to prevent erosion.

In order to avoid thermal erosion above a buried pipeline carrying hot oil, where revegetation is impossible on account of the high temperature of the surface soil, it is recommended that the route be covered with gravel[2].

These studies, along with an assessment of the economic expediency of a project, taking into account possible damage to other industries, must be undertaken before taking a decision on a large-scale project, not afterwards. This work is very costly and sometimes extends over long periods, but it is essential.

And, lastly, consideration should also be given to forecasts of general changes in the world's climate, the consequences of which will be of particular significance for the North. On the one hand, the 1960s saw the beginning of the current cooling phase in the North (such fluctuations have a period of several decades), on the other, according to some estimates, it is possible that the lower layers of the atmosphere will warm up as a result of an increase in the content of CO_2. The ecological consequences of such events should be studied and forecasted.

<u>Improvement of the natural environment in the vicinity of settlements, transport centres, and mines.</u> Urban and industrial ecosystems, created as the result of the development of industry, construction, and transport in the North, still occupy a relatively small area. Within the next few decades this area will increase, but, even then, it will remain proportionately small in relation to the total territory of the North, and the effect of such ecological systems on the natural surroundings will, in the general case, be localized, although some pollution may be fairly widespread. A number of "sections" of these

ecosystems may even have increased productivity compared with natural ecosystems; on the whole, however, territories fully transformed by man in the North, together with their environments, are rapidly reduced to "anthropogenic deserts". The productivity losses sustained by the reindeer husbandry and hunting industries in these territories are, on the whole, not all that significant. However, as the population increases, the territories will become increasingly important for recreational purposes.

The extraction of minerals inevitably entails the construction of approach roads, the granting of leases, the excavation of shafts and quarries, and the appearance of enormous dumps. The natural vegetation is destroyed, which in permafrost regions results in disturbance of the thermal balance and the development of denudation, erosion, and thermokarst. In addition, river beds widen and deepen, and lakes dry up. The direction of permanent water courses and their rate of flow are altered, the turbidity of the water increases, channels silt up, the sandy gravel, in which fish deposit their eggs, is either buried or carried away. Aquatic and terrestrial ecosystems are polluted by toxic substances contained in dirt or washed out and carried away from mining regions. The acidity of water bodies increases. Changes in the chemical composition of soil, ground and surface water lead to corresponding changes in the soil microflora, fauna, and hydrobionts, the accumulation of chemical elements in organisms, as well as the environmental pollution described above.

Drilling mud, free oil, and sedimentation block and contaminate waterways. The problem of clearing the surface of salt water used in well drilling has not yet been solved. The H_2S and SO_2 given off during the production and refining of oil and gas contribute to higher levels of soil acidity. Fires are unavoidable in the exploitation of oil and gas resources. A fire on the tundra is capable of transforming a region with a stable vegetation cover into a lifeless swamp, with very serious consequences if it happens in a catchment area.

Neither the ecological consequences of the complete transformation of ecosystems, which takes place around settlements, transport and industrial installations, nor the scientific principles of environmental amelioration in such places have yet been studied anywhere, although work on these problems has been started. Technical methods of minimizing the silting up of water bodies

are being developed. According to scientists, the problem of waste removal on the tundra can be solved by the high-temperature incineration of organic waste, by using liquid waste as fertilizer, by deep burial, or by collecting and transporting the waste to nonpermafrost regions[18].

The above-mentioned influences of industry and human settlement on the natural environment will subsequently increase. Therefore, it is necessary: a) to determine the damage which reindeer husbandry and hunting could suffer as a result of reduced productivity of the surrounding areas; b) to work out measures to reduce this damage (for example, the removal of certain chemicals from tailings and outflows, if this proves necessary; the formulation of standards of industrial activity in the North, etc.); c) to develop means of accelerating the biological decomposition of industrial and domestic waste; and, d) to devise ways of recultivating land damaged by mining operations.

Concerning administrative measures, it should be noted that in Canada, for example, 1971 saw the introduction of the Land Use Rules, differentiated according to the economic-geographical zones of the North; the establishment of fees for the right of land use for industry and transport and the fixing of high guaranteed payments out of which funds are withdrawn to compensate for environmental damage; the introduction of special Rules for Oil and Gas Exploration and Production, the purpose of which is the protection of the natural environment[13]. Similar measures were adopted in Alaska. However, all these are administrative actions prompted by urgent necessity, but as yet they have not been adequately substantiated by scientific data.

The effect of the growth and mobility of the population, recreation, and tourism on the natural environment. The population of the North will expand rapidly in the next 30 - 40 years. The fact that the numbers of permanent inhabitants in rural areas, remote and inaccessible parts of the taiga and the tundra show only a slight increase means that most of the population growth will occur in urban-type settlements serving industrial, transport, and other installations, and because of numerous expeditions, prospecting teams, construction workers, etc. The relatively large numbers of tracked, high-speed water and air transport machines, which can be used both by the inhabitants

of the settlements and by expeditions, brings the vast territories of the North within comparatively easy reach. Light snowmobiles, like those now in widespread use in the U.S.A., Canada, and Scandinavia, will soon be produced in the U.S.S.R. The number of people, including tourists, who spend their holidays in the North, is rapidly increasing and will increase even more in the future.

As a result, we are faced with a situation in which there are increasing possibilities of uncontrolled penetration of and activities in the taiga and tundra by large numbers of people who do not know how to behave properly in the countryside. This could lead to a serious deterioration of forest renewal conditions, fires* which destroy forest and deer pasture, poaching, environmental pollution, changes in the condition of the lakes, transport erosion, etc.

Apart from administrative protective measures, which are needed immediately**, it is essential to work out norms of "recreation loads" on northern ecosystems and ways of regulating them within limits which will ensure the preservation of the ecosystems. Such studies have now been initiated in Alaska and should be organized in our country as soon as possible.

The recreational importance of the North will increase greatly in the future. The effect of transportation systems on the recreational qualities of the terrain, the condition of lakes, waterways and reservoirs and the abundance and behaviour of animals should be forecasted and regulated.

The creation of specially protected areas. As the pace of industrial development in the North increases, so will the ecological importance of areas where all forms of economic activity are prohibited (zapovedniki†) or where certain economic activities are prohibited (zakazniki†). Their scientific value consists in the fact that they will serve as a standard for the study of the normal functioning of ecosystems, as a means of constantly checking processes occurring in areas that are being exploited, and as a basis

* In Canada, for example, as much as 29% of the winter browsing grounds of caribou have been destroyed by fire (6).

** In northern Alaska oil companies prohibit the keeping of guns in oil workers' camps (18).

† See Glossary. (Transl. Ed.)

for devising ways of making the best use of the biological resources. In practice, these areas will be preserves of the entire genetic stock of arctic and subarctic animals and plants, in particular of valuable migrating animals, which pass through one or more of the most important stages of their biological cycle within their boundaries (birds, reindeer, polar bears, etc.), including those that are harvested on a continental scale, chiefly in more southerly latitudes (aquatic birds). These areas will also play an important cultural, educational and recreational role. At present there are two such zapovedniki in the Soviet Far North (both on the Kola Peninsula), the total area of which is 1,900 km^2, and several zakazniki. In the future it will be necessary to increase both the number and extent of such protected areas. In the U.S.S.R. zapovedniki and zakazniki should first be established on the shores and islands of the Khaipudyrskaya Guba, on Vaigach Island, in western Taimyr, in the Lena Delta, in the Yana-Indigirka Lowlands, and on the north shore of the Chukchi Peninsula. Subsequently it will be necessary to work out in detail a rational network of different types of protected areas in the North, taking into account the present distribution of animals and plants, the principal biological resources and the main types of ecosystems, as well as geological forecasts, the prospects of developing reindeer husbandry and other industries, and the scientific and recreational possibilities. Such studies are being conducted in the U.S.S.R., Alaska (where there are several national parks and zakaznik-type reserves which, taken together occupy 11% of the entire area of the state), and northern Canada (where there is one national park, and four more are being created). Similar projects have also been initiated on Spitsbergen. The theoretical principles of setting up protected areas and an actual network of them in the Soviet North should be worked out as soon as possible.

<u>Questions relating to the organization of research work.</u> In prospect the study of scientific problems of nature conservation in the North should be conducted along two lines: 1) in depth studies and modelling of the dynamics of natural processes based on a network of permanent stations; 2) extensive studies of the state of biological resources and anthropogenic changes in the environment on a broad geographical scale.

Practical nature conservation measures should be planned and carried

out on a differential basis for individual geographical zones, which differ both in the characteristics of their ecosystems and in the ways in which they are being economically developed. Investigations should be conducted on a large scale simultaneously in the main geographical regions and zones. Parallel studies should be conducted in places where there is intensive economic activity and in places where there is practically none. It is essential to maintain uninterrupted collection of information on the course of natural processes in natural and anthropogenic ecosystems, thus making it possible to forecast the situation and recommend sound administrative decisions without delay. Ecological research should precede these decisions, rather than analyze their consequences.

Special research on nature conservation problems is as yet a rarity at Soviet research stations. The above-mentioned problems should be included in their work program. For this purpose it would suffice at many stations to enlist new specialists in this work, having achieved the appropriate inter-departmental coordination. In other places (for example, regions where oil, gas, coal, gold, and tin are being extracted at an intensive rate, in new construction areas) new stations would need to be set up.

Questions relating to the protection of the biological resources and ecosystems in the Soviet North are studied at institutions of the Academy of Sciences of the U.S.S.R., its Komi and Yakutsk branches, the Ural and Far East science centres, the Ministry of Agriculture of the U.S.S.R., the Main Administration of Hunting and Zapovedniki* of the R.S.F.S.R., the Central Union of Consumers' Societies**, the Main Fisheries Administration***, as well as in a number of universities, etc. However, the volume of research work on these problems is inadequate in nearly every case.

Research work in this field abroad was greatly stimulated by the discovery of oil in Alaska and the prospects of finding oil and gas deposits in the Canadian Arctic, and now on Spitsbergen. Ecologists and engineers are co-operating on research aimed at working out a northern development technology

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* "Glavokhota". (Transl.)

** "Tsentrosoyuz". (Transl.)

*** "Glavrybvod". (Transl.)

which takes into account the specific features of northern ecosystems and causes the least disturbance and pollution to the natural environment. This kind of approach and work organization has proved fruitful, and the results are positive. In addition to the projects already referred to, there are others with a more comprehensive approach which should be mentioned.

In Canada the Department of Indian and Northern Affairs, the main oil companies operating in the Mackenzie Delta (Arctic Petroleum Operators Association), and scientists from a number of universities have, since 1970, been cooperating in a comprehensive program of "Arctic Land Use Research" (ALUR). The aim of the program is to study disturbances caused by geophysical and oil exploration activities, tracked vehicles, the emergence of roads, settlements, etc., and their effect on natural complexes. The ecological effects of oil on plant life, soil invertebrates and ground water movement are being revealed. The natural decomposition rate of spilled oil and ways of accelerating it will be studied.

In conformity with the ALUR program a series of information maps (scales 1:125,000 and 1:250,000) is being compiled. These reflect the biological potential and stability of ecosystems, the possibilities of their utilization, the distribution of biological resources, regions of special ecological importance, the distribution of the hunting and fishing industries, etc. Biological (especially animal) resources, regions of proposed national parks, and other ecological reserves are studied in great detail. These investigations will make it possible to forecast the effect of a reduction in the numbers of wildfowl, fish and sea mammals on the life of the native population, the long-term effects of industrial development on natural complexes and the cost of restoring the natural environment[1,13].

Investigations have been started in regions where the surface has been disturbed in the past in order to determine the most vulnerable types of soil and vegetation and the plants which have invaded such disturbed surfaces. As a result it is proposed to ascertain the plants and protective soil covering for seedlings which should be used to accelerate the restoration of the disturbed surfaces and to eliminate thermokarst development, where possible[2].

Research is being conducted to determine the functioning of natural ecosystems, as well as of ecosystems in places that have been subjected to the action of oil spills, fires, tracked vehicles, road construction, etc. The studies should determine the influence of such factors and the over-all safe limit beyond which an ecosystem will not continue to function[1,19].

In addition to Canada, similar research is being conducted in Alaska and has now been started on Spitsbergen, where an intensive search for oil has been in progress for several years.

Of great importance to nature conservation on the tundra is the work of the International Biological Program, which correlated the data of previous studies conducted in Alaska and Canada and made it possible to obtain a clearer picture of the basic characterists of tundra ecosystems. The "Sea-Grant" Program of marine environmental research[18] was started recently.

Under the conditions in the Soviet Union research on nature conservation in the North should be coordinated on a nation-wide scale. Large-scale comprehensive interdisciplinary research projects aimed at the solution of specific problems (the ecological evaluation of projected hydro-electric power stations, pipelines, etc.) should be put into effect. These projects should be carried out over a period of several years with large-scale resources and include ecologists, engineers, and specialists with various qualifications. All interested departments should participate on a proportional basis under a single managing body. Ample funds should be allocated for these projects, a large proportion of which, in our opinion, should be contributed by the sectoral ministries responsible for industrial activities in the North. Of course, a situation should be created in which departments engaged in exploiting natural resources in the North would be financially interested in ensuring that their activities did not cause damage to the natural environment.

The adoption of administrative decisions relating to the development and regulation of industrial activities which can affect the natural environment of the North should be preceded by a government statement of the scientific problems involved.

Needless to say, it is important that the practical solutions resulting from the investigations should be implemented. As a rule, full implementation is not possible at individual departmental level, and better co-ordination of the activities of the departments concerned can be achieved through a superdepartmental body invested with the appropriate powers.

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PROBLEMS OF FOREST MANAGEMENT IN THE NEAR NORTH OF THE U.S.S.R.

Introduction. For many thousands of years forests were valued primarily as a source of wood. Sporadically, forests were also used for other purposes. But any wider use of forest resources for purposes other than wood was not known until just a few decades ago.

In our time the systematic use of forests has taken three main directions: 1) as a source of wood and of nonwood products (various forms of food resources, fruits, berries, mushrooms); 2) as a physical and geographic factor, i.e., as a protection, as a means of water conservation, as an anti-erosion and climate-regulating factor; 3) as a determinant of social and cultural life, specifically its sanitary-hygienic, recreational and esthetic aspects.

The advancing rate of urbanization, the population explosion, the increased number of industrial enterprises, the proliferation of transportation networks, the more intensive use of river systems, have all been instrumental in bringing to the fore, in many regions of the world, the importance of forests, from a physical and geographical as well as a socio-cultural point of view.

In principle this is applicable to all regions of the world. It is not by accident that the VII World Congress held in Argentina (1972) concentrated its work to a considerable extent on the issue of how to utilize and preserve forests in the most appropriate way, stressing their function as a component of the environment. Furthermore, in the Congress Declaration a demand was made to consider the need to regulate all forms of forest use while providing for the compulsory preservation of the physical and geographic as well as the socio-cultural significance of stands.

There is no doubt that great importance must be attached here to

Problemy Severa, (18): 32 - 49, 1973.

the nature of a region, the degree of its industrial development, the density of population, and finally, the extent of forest cover.

The regions of the European and Asiatic North of the U.S.S.R., if we accept their conventional limits (as established by the Council for the Study of Resources), extend over approximately 555,000,000 hectares of forest area* and have a stand of 47 billion m^3. These forests constitute 60% of the overall forest area of the U.S.S.R. and 14% of the world forest resources.

The forests and the forest-growth conditions of these regions have been studied for many years by representatives of a number of sciences: geography, botany, silviculture, forest management, and so on. The study of the geographical change patterns of tree species within the limits of the region under review has shown that, depending upon the latitude in which they are found, the composition of the forests changes considerably, in the first instance through the presence or absence of warmth-loving species, the level of productivity of the forests, the quality of stands, and so on.

The longitudinal pattern is reflected primarily in the nature of distribution of tree species having different demands with respect to the amount of moisture in the air.

Bearing in mind these special features, research workers have singled out three subregions in the taiga zone: northern, middle and southern. The general pattern of regional classification of Siberian and Far-Eastern forests is given by G. V. Krylov[7]. According to this pattern, the middle subzone of the taiga consists of stands which are relatively homogeneous in terms of forest growth conditions and species composition.

However, when considering the economic aspects in the section of studies dealing with the opening of the forests, more attention must be paid not

* The forest resources are computed in the U.S.S.R. according to a three-step system showing: 1) the forest-covered area; 2) the forest area, i.e., area covered with forests and not covered, the latter being made up of logged-out areas, areas previously logged-out and not reforested, stands too thin for logging operations, and so on; and 3) overall area of lands with forest resources, which includes various types of land not covered with forests but which lie within the limits of the forest resource area.

only to the composition and the type of forests, but also to the extent to which they are accessible. An issue of even greater importance is the consideration of the conditions and the sequence of their becoming available for development. Furthermore, attention must be paid to transportation links, the extent to which given resources gravitate towards wood-consuming centres, the development of various sectors of the national economy within the region, and so on.

The limits of the Near North zone, delineated by boundaries established with the above considerations in mind, do not naturally correspond fully to the forest growth regions, although the southern limit does extend along the same boundary as the middle subzone of the taiga. The northern boundary coincides with it as far as the boundary of the Krasnoyarsk Krai. It does not include the Tungus part of the spruce and larch forests of the Krasnoyarsk Krai and the greater portion of the Vilui-Aldan larch and pine forests of the Yakut A.S.S.R.

The forests of the European North lie essentially within the middle subzone of the taiga, and in places (north of Arkhangel'sk Oblast, Komi and Karelian A.S.S.R.) in the northern taiga.

Of the forest area of 555,000,000 ha mentioned above, 250,000,000 ha are in the Near North zone. In these regions, as everywhere else in the country, at the present time a process of intense economic development has begun. From year to year an increase can be seen in the number of industrial enterprises, in the network of roads, and number of inhabitants and so on. However, the forest resources of this area are such that for many decades they will be a factor of world-wide importance in the maintenance of the oxygen balance in the earth's biosphere, in the harmonious development of the plant and animal world, and in hydroclimatic and other similar phenomena. According to available calculations[(2)], the world's forests produce annually 20,000,000 - 28,000,000 tons of organic mass, i.e., two thirds of the entire organic mass synthesized on land.

If we consider that the organic mass created by the forests corresponds essentially to the magnitude of the annual growth increment of the

forests, then the role of the northern forests in oxygen exchange probably amounts to not less than 14 - 15% of the entire annual exchange. The role of the northern forests in regulating the climate of Eurasia is well known.

With the increase in the significance of forests of the North in the economic life of the country, the necessity arises for substantially increasing and organizing the entire system of measures for protecting forests in these latitudes. These matters are particularly urgent in the zone of the so-called reserve forests, whose areas are very large, but their status in many respects does not correspond to the requirements of up-to-date forestry management.

It is clear that within the next few years the forests of the North, both in the European part of the country and in the East, will be considered primarily as wood resources of the national economy. For this reason, in the present publication we shall also consider in greater detail the problems connected with these resources.

In the forest resources defined as being of significance to the national economy, the areas of reserve forests relegated to Group III exceed 250,000,000 ha. Of these, 22,600,000 ha are in Western Siberia, 105,700,000 ha are in Eastern Siberia, and 110,800,000 ha in the Far East. As a rule, these forest areas are far removed from transportation lines and include large tracts of low-grade forests, some of which grow in mountain areas not easily accessible. Up to the present, logging operations have been extended only to some southern stands of the reserve forests, and to isolated sectors farther north in areas where various mineral resources are being developed, where road construction is taking place, etc.

However, with the enormous economic uplift of the eastern regions of the country, this state of affairs cannot continue for long. The regions of Siberia and the Far East are faced with the need to increase further the volume of logging. This is brought about, on the one hand, by the fact that from year to year these regions themselves need more and more wood. In 15 to 20 years large pulp and paper enterprises will be built. There will be a considerable increase in the production of lumber, plywood, wood-based boards, hydrolysis

products, and so on. On the other hand, the importance of Siberia and the Far East increases steadily as these regions become the suppliers of wood to the European part of the U.S.S.R. and the regions of Central Asia. There will also be an increase in deliveries from these regions to export markets. In the region of the European North arises the problem of how to increase forest resources in the course of their reforestation, keeping in mind the needs of other regions and the interests of the export markets.

All this will bring about a further considerable change in the position and the role of Siberia and the Far East in the development of the forest industry of the U.S.S.R. According to available calculations of the planning institutes, the volume of logging in the European part of the U.S.S.R. - even taking into account the possible utilization of broadleaf species - can be raised at the most from 270,000,000 m^3 at the present time to 300,000,000 m^3 in the next decade. At the same time, according to our preliminary estimates, the overall demand of the country for wood will soon rise from 400,000,000 m^3 to 500,000,000 m^3, and following that, to 550,000,000 m^3. This will require a corresponding increase in the volume of logging in Siberia and the Far East from 125,000,000 m^3 at the present time to 200,000,000 - 240,000,000 m^3 and more in the future.

Against the colossal annual increment of wood in the forests of Siberia and the Far East (amounting to 558,000,000 m^3), the future logging volumes outlined above do not appear to be large. But it must be borne in mind that more than half these forests are of nonconifer species and larch, which has found very little use in industry. In the zone where forests are harvested, of the 205,000,000 ha containing the main forest-forming species, the main industrial species (pine, spruce, fir and Siberian pine) occupy only 74,000,000 ha. Consequently, apart from utilizing the stands of larch and broadleaf species, the main condition for a further increase in the volume of logging is the gradual opening of huge areas of forests heretofore untouched. The forest industry organizations consider that the solution of this problem demands an overall acceleration of effort in the construction of a railroad along the northern latitudes, as well as a number of roads of local importance.

<u>Forest resources of the northern regions of the U.S.S.R.</u> From the

point of view of development, several zones in the territory of reserve forests can be singled out for exploitation. The first to be developed will be the virgin forest areas of the Near North, amounting in all to 3,300,000 km^2. Two-thirds of these areas are forest-covered. This zone stretches in the form of a wide band from the Karelian A.S.S.R. to the eastern borders of the country, embracing completely or in part the forest stands of the Karelian A.S.S.R., Arkhangel'sk Oblast, Komi A.S.S.R., Tyumen and Tomsk oblasts, Krasnoyarsk Krai, Irkutsk and Chita oblasts, Yakut and Buryat A.S.S.R., Amur and Sakhalin oblasts and, finally, Khabarovsk Krai.

The forests located in these areas have, in recent years, been included in the existing inventorial system, but they have been assessed with varying degrees of accuracy. Making use of the available material from inventory-taking and timber sales, let us consider the distribution of the forest-covered area according to the main forest-forming species and the timber stands they provide. Let us also consider various quality indices, certain data on forest use, and so on, selecting that information which pertains to the Near North. The overall information on the forest resources (which are under the control of the forestry management organizations) in the oblasts listed above is given in Table I.

As shown in the data in Table I, conifer species predominate in the Karelian forests, making up 88% of the forest-covered area. Pine occupies 62% of the area, spruce 28%. Their stands amount to 61% and 31% of the overall stand of the oblast. Compared with other forests of the European North, the Karelian forests are the most productive. They are generally of class IV - V quality (76% of the forest-covered area); class III quality stands extend over 13% of the area; class II and above occupy 3.5% of the area. The average stand per hectare in the mature and over-mature forests is 136 m^3, while the average annual increment is 1.26 m^3. The Karelian forests no longer have any reserve areas. Calculations carried out by a number of research organizations have shown that, even if the present level of logging is continued for the next 5 - 8 years, that is, at a rate of 16,000,000 - 17,000,000 m^3, in 15 to 20 years the annual allowable cut will have to be reduced (in view of the depletion of reserves of mature wood stands) to 8,000,000 - 6,000,000 m^3. All the forests of Karelia

Table I

Forests growing on territories lying fully or partially within the zone of the Near North of the U.S.S.R.

Oblast, Krai or A.S.S.R.	Forest areas, mil. ha		Relative share of conifers, %	Timber stand bil. m^3		Relative share of mature and over-mature %	Reserve forests in Group III	
	Total area of forest lands	Forested area of forest lands		Total	Mature and over-mature		Forested area, mil. ha	% of total area
Karelian A.S.S.R.	14.7	7.9	88	0.91	0.60	66	-	-
Arkhangel'sk Oblast	27.4	19.3	88	2.25	1.94	86	3.1	16
Komi A.S.S.R.	37.7	27.6	81	2.74	2.38	87	1.4	5
Tyumen Oblast	90.2	43.5	73	4.76	3.75	79	17.8	41
Tomsk Oblast	27.1	16.3	51	2.27	1.73	76	3.2	19
Krasnoyarsk Krai	145.2	106.8	82	14.22	11.28	79	56.9	53
Irkutsk Oblast	68.9	55.1	80	8.03	5.83	73	25.8	47
Chita Oblast	32.4	23.2	82	2.25	1.36	60	9.6	41
Buryat A.S.S.R.	27.6	17.7	83	1.90	1.30	68	7.7	44
Amur Oblast	31.0	19.4	76	2.10	1.47	70	11.2	58
Khabarovsk Krai	54.9	38.3	80	4.88	3.62	74	18.8	49
Sakhalin Oblast	7.2	4.5	70	0.64	0.50	78	1.0	23
Yakut A.S.S.R.	213.8	119.0	93	10.52	7.83	74	71.8	60

have been cruised at the III and II category of accuracy. This territory lies entirely within the zone of the Near North.

Arkhangel'sk Oblast, like the Karelian A.S.S.R., lies within a region with a limited allowable cut, where the volume of logging must be reduced in the near futre. Here, too, conifer species predominate. Spruce is the leading species, comprising 62% of the forested area and 71% of the stand, pine accounts for 26% of the stand and 23% of the forest-covered area. Reserve forests amount to 16% of the overall forest area of the oblast. Of the forests of Arkhangel'sk Oblast, 78% are classed as being of IV - V quality, 14% fall within class V(a) and lower, and only 8% of the forests are placed in class III quality and higher. The volume of logging over recent years has remained at 24,000,0000 - 25,000,000 m^3, which is almost 100% of the allowable cut. Further development of the forest industry in the Arkhangel'sk Oblast is possible only within the limits permitted by the available reserves of broadleaf species and the volume of various types of wood rejects. Eighty-six percent of the forests in the Oblast are cruised. Except for Mezen Leskhoz (a logging enterprise), the entire Arkhangel'sk Oblast lies within the zone of the Near North. The Mezen Leskhoz area of forest amounts to 3,000,000 ha with a stand of 0.15 billion m^3.

Among the forest-rich areas, where the forest industry can and will develop quickly, are: Komi A.S.S.R., Tyumen and Tomsk oblasts, Krasnoyarsk Krai, Irkutsk Oblast and part of Chita Oblast, the Buryat A.S.S.R., Amur Oblast, Khabarovsk Krai, and Sakhalin Oblast.

In the forests of Komi A.S.S.R., as everywhere in the North, conifer species predominate. Spruce makes up 55% of the forest-covered area and pine 25%. Their stands account for 70% and 20%. In the forests here, stands of IV - V quality also predominate, accounting for 62%. Class V(a) and below account for 30% of the area. On the remaining portions of the territory are forests of grade III, II and above. The annual increment is only 0.89 m^3, while the average stand per hectare in the mature and overmature forests amounts to 110 m^3. In 1970, 21,000,000 m^3 were logged in this area, representing 59% of the allowable cut. Here it is planned to expand a number of the existing forest industry complexes and create some new ones. Of the forests of the Republic, 58% have been cruised,

essentially at III and IV class standards. The remaining forests have been assessed by means of air survey. The entire Komi A.S.S.R. lies within the zone of the Near North.

Thirteen logging enterprises in Tyumen Oblast lie within the zone of the Near North. They have a combined area of 47,500,000 ha, of which 23,800,000 ha are forest-covered. Conifer species predominate in the forests, accounting for 68.7% of the area and 75.2% of the stand. The total stand of the forests is estimated at 2,700,000 m^3 [should be 2.7 billion - J.S., translator], which is equal to 56% of the stand in the Oblast. Mature and overmature forests constitute 76% of the total (54% of the stand of mature and overmature stands of the Oblast). The forest cover in this part of Tyumen Oblast is 45.5% (the forest cover of the entire Oblast is 31.2%). The volume of logging here is almost 50% of the volume of logging in the Oblast as a whole. Of the 47,500,000 ha of forests, a portion has been cruised (48%), the remaining forest territories having been assessed by air-survey methods.

In the Tyumen forests, pine predominates (38% of the area and 41% of the stand), followed by Siberian pine (14.8% and 17.7%), spruce (10.2% and 11.2%), and larch (9.1% and 10.1%). The area of the reserve forests amounts to 41% of the entire forest-covered area of the Oblast. Stands of IV - V and V(a) quality and below predominate in the forests. The average increment in the Tyumen Oblast is 1.03 m^3. The volume of logging is growing from year to year. In 1970 the volume of logging amounted to 21% of the allowable cut, as compared with 17% in 1965. The forests of the Tyumen Oblast are singled out to become one of the wood-supply bases for the future large-scale forest industry of Siberia.

The forests of Tomsk Oblast, the bulk of which falls within the limits of the Near North, are mainly of class III and IV - V quality (78%). Forests of II quality and higher cover an area in excess of 2,000,000 ha (13%).

The forests of Tomsk Oblast contain a large percentage of broodleaf species. These represent up to 49% of the forest-covered area. Birch makes up 40.1% and aspen 8.8%. Conifer species make up 51% of the area. Of these, pine occupies 28.1%, Siberian pine 18.3%, spruce and fir 4.6%. The average valuation composition of the stand for pure species of mature and overmature stands is as

follows: 3P3SP3B1As + F [P = pine, SP = Siberian pine, B = birch, As = aspen, F = fir]. All the forests of the Oblast have been cruised, essentially at III and IV levels of accuracy. The area of reserve forests amounts to only 19%.

From Krasnoyarsk Krai, in the Near North zone, there are only five logging enterprises, namely North-Yenisei, Yenisei, Boguchany, Ust-Angara, and Prospikhinskii, in which the forests amount to 19,500,000 ha (13% of the forests of the Krai) and 16,600,000 ha of the forest-covered area (15%) with a stand of 3.1 billion m^3, of which 2.4 billion are mature and overmature (approximately 80%). This amounts to 22% of the total stand of the Krai, and 21% of the mature and overripe stand. The stand of conifers is in excess of 80%. The forest cover of this portion of Krasnoyarsk Krai is very high, reaching 83%, while the forest cover of the entire Krai is only 26.7%. The volume of logging in these forests amounts to about 20% of the overall volume taken out in the Krai. Of the 19,500,000 ha, about 78% have been cruised, essentially at III and IV levels of accuracy.

In the forest resources of Krasnoyarsk Krai, conifer species predominate (82%). The composition of the forests is represented by the formula 3L2P1F1S1SP2B + As [L = larch, S = spruce]. Larch occupies 48.3% of the forest-covered area and constitutes 41.2% of the area's stand. The figures for pine are 10.6% and 14.5%. Siberian pine occupies 9.7% of the area and makes up 14.6% of the stand. The figures for spruce are 8.9% and 11.3% respectively. The proportion of fir in the Krai's forests amounts to 4.4% of the forest-covered area. Within the Krai, forests of IV - V and V(a) grade and below predominate. An area of 25,000,000 ha is covered with high-productivity forests of III and II grade and above. In 1970 the volume of logging was less than 32% of the allowable cut. The percentage of forests in the Krai which have not yet been cruised is very high, amounting to 53%.

Only part of Irkutsk Oblast belongs to the Near North zone. The territory belonging to the zone has an overall forest area of 30,900,000 ha while the forest-covered area amounts to 25,300,000 ha. The timber stand here is estimated at 3.5 billion m^3 (40% of the stand of the entire Oblast); furthermore, mature and overmature stands make up 70% (39% of the mature and overmature stands of the Oblast).

In the forests, conifer species predominate (78%). The forest cover in this portion of Irkutsk Oblast is very high, being 83.6%, while the forest cover of the entire Oblast is 75.7%. All the forests have been surveyed, 46% have been cruised, and the remaining areas have been assessed by means of air survey.

The forests of Irkutsk Oblast are noted for being high-density, highly-productive stands, where grades of III and II quality and above predominate. The average volume per hectare in mature stands is high: close to 180 m^3, the average increment is 1.58 m^3. In the forests valuable conifer species predominate: pine, larch, spruce, Siberian pine, and fir. Pine occupies 28.5% of the forest-covered area, larch 33.6%, Siberian pine 10.5%, spruce and larch 7.2%. In terms of the stand, pine is in first place, providing 36%, then larch 33%, Siberian pine 13%, spruce and fir 8% of the total stand. The proportion of reserve forests in the forest-covered area is also very high, being 47%. The volume of logging in the Oblast is 25,000,000 m^3, which is 40% of the allowable cut.

Four logging enterprises of the Chita Oblast lie within the Near North zone: Tungokochenskii, Charskii, Tungiro-Olekminskii, and half the territory of the Nerchinskii enterprise. The total area of these forests amounts to 13,800,000 ha, of which the forest-covered area is 8,400,000 ha. The stand in the forests amounts to 0.7 billion m^3, of which mature and overmature are 0.6 billion m^3. Conifer species occupy 79% of the forest-covered area. The conifer stand amounts to 92% of the total stand. The volume of logging in these territories amounts to only 4% of the total volume of logging in the Oblast. Of the forests, 96% have been surveyed visually from the air.

Of the overall forest area of the Chita Oblast, amounting to 32,400,000 ha, 41% are reserve forests. Conifer species also predominate (82%), mainly larch, which accounts for 68.9% of the area and 75.7% of the stand, followed by pine (approximately 10% of the forest-covered area and 11.6% of the stand). Siberian pine, spruce, and fir occupy only 4% of the area. The forests are primarily of IV - V quality. The average stand per hectare is 103 m^3. The volume of logging in the Oblast is close to 5,000,000 m^3.

Two logging enterprises of the Buryat A.S.S.R. lie within the

Near North territory. These are the Angara and Vitim enterprises, with an overall forest area of 13,000,000 ha, and forest-covered area of 7,000,000 ha. The stand in the forests of these enterprises amounts to only 771,000,000 m^3. The stand of mature and overmature is 534,000,000 m^3. The forests are predominantly conifer (85.5%). The forest cover of the enterprises' territory is 52%. Of the forest area, 35% has been cruised, the remainder having been assessed by air-survey methods. The volume of logging in the entire territory of the Oblast is close to 5,000,000 m^3, while the removal of wood from the two enterprises mentioned above is quite insignificant, amounting to 130,000 m^3.

In Amur Oblast, the logging enterprises belonging to the Near North zone are: Dzheltulak, Zeya, Mazanovo,and Ekimchan, with a joint area of forests equal to 23,600,000 ha, of which 15,000,000 ha are actually forest-covered. The total stand is 1.7 billion m^3, the conifer stand is 1.6 billion m^3. Mature and overmature stands make up 70%. Forest cover in this part of the Oblast is 69%. The volume of logging in these forests amounts to 26% of the overall volume of logging for the Oblast. With respect to the extent of forests surveyed, over 40% have been cruised and the remainder surveyed from the air.

In the Amur Oblast, the principal species is larch, which occupies 71.8% of the forest-covered area and provides 83.5% of the overall stands. Of the broadleaf species, birch amounts to 18.9%. Commercially valuable Mongolian oak is found, occupying an area of 331,000 ha. Predominant are forests of IV - V quality, with an average volume per hectare equal to 110 m^3. The area of virgin forests is very high, amounting to 57.6% of the forest-covered area of the Oblast. Furthermore, a considerable share is made up of forests located in inaccessible mountainous regions. The volume of logging in the Oblast is close to 4,000,000 m^3.

Eight logging enterprises of Khabarovsk Krai fall within the Near North zone. Their combined forest area is 19,300,000 ha, while the forest-covered area is 13,700,000 ha. The volume of stand in these forests amounts to 1.8 billion m^3 (nearly 36% of the stand in the Krai). Mature and overmature stands amount to 1.3 billion m^3 (72%). Conifer species make up 88% of the forest-covered area. Forest cover amounts to nearly 78%. The volume of logging from these forests amounts to 20% of the overall logging in the Krai. The forests have not

been sufficiently well surveyed as yet. Eight million hectares have been cruised, while the remainder of the territory has been surveyed visually from the air.

The average specie composition formula for the forests of Khabarovsk Krai is as follows: 4L3S1SP1F1B + Ln,As,O [Ln = linden, O = oak]. Larch occupies 51% of the area and gives 45% of the stand, spruce figures are 24% and 35%, Siberian pine 4% and 7%. Approximately 1% of the area and of the stand are pine and fir. Of the broadleaf species, birch accounts for 6% of the area. Of industrial importance are ash, which occupies an area of 162,000 ha, and Mongolian oak, covering an area of 842,000 ha. Within the Krai, forests of IV - V and III quality predominate. The most productive forests are in the southern part of the Krai. Virgin forests occupy 48.5% of the area. The volume of logging in 1970 was close to 13,000,000 m^3.

Only two logging enterprises of the Sakhalin Oblast fall within the Near North zone: Okha and Nogliki, with a combined forest area of 2,200,000 ha, of which 1,100,000 ha are forest-covered. The timber stand on them amounts to 0.17 billion m^3. In these forests, conifer species occupy 88% of the area and make up 96% of the stand. The forest cover is 41%. The enterprise forests have been essentially cruised (approximately 90% of the forest area).

In the Sakhalin Oblast, forests of IV - V quality predominate. Conifer species prevail. Spruce makes up 30% of the area and nearly 50% of the stand, larch 29% and 27%. The specie composition for the forests can be expressed as: 6S3L1F + B,SP,Pop[poplar]. The percentage of reserve forests is relatively low, amounting to 24.6% of the overall forest area. The volume of logging in 1970 was 3,400,000 m^3.

The Yakut A.S.S.R. is a region with relatively limited possibilities for the development of the forest industry, but it has extensive forest areas, which are in excess of 213,000,000 ha. The forest-covered area amounts to 119,000,000 ha, which is only 55% of the total forest area. In the forests conifer species predominate, accounting for 93% of the area and 98% of the stand. The area is mainly overgrown with larch, which occupies 86% of the area and accounts for 86% of the stand of the Republic. The species composition formula is: 10L + P, and single stands of pine, Siberian pine and beech. In the Yakut A.S.S.R. the highest percentage of virgin

forests is found, amounting to 60% of the forest-covered area. The volume of logging in 1970 was 3,800,000 m^3.

The Vitim, Lena, Olekma, Aldan, and Timton logging enterprises of the Yakut A.S.S.R. lie within the Near North zone. The combined forest area is 47,500,000 ha, of which 37,000,000 ha are forest-covered. The timber stand in these forests amounts to 4.6 billion m^3, of which 3.9 billion m^3 are mature and overmature. Conifer species occupy 92% of the forest-covered area and have a stand of 4.5 billion m^3 (99% of the overall stand). The forest cover in this part of Yakutia is higher than that of the Republic as a whole, amounting to 75%. Nearly 35% of the wood cut in the Republic is logged in these forests. The forests have not been adequately surveyed as yet. Seven million hectares have been cruised, which amounts to 15% of the forest area. The remaining territories have been surveyed by air-survey methods and visual studies from the air, which give only an approximate picture of the forests and forest resources.

Let us sum up some of the data of the survey of the resources of the Near North by oblasts. The forest area of the Near North amounts to 317,000,000 ha, or 27% of all the forests in the country. The forest-covered area amounts to 215,000,000 ha, or 31% of the total. On the Near North territory are forests with a joint stand of 27 billion m^3, which constitutes 35% of the overall stands, of which reserves suitable for use amount of 21 billion m^3, or 28% of the total usable forest resources of the U.S.S.R. Of the 27 billion m^3 of total forest resources of the region, 17% is found within the territory of the Yakut A.S.S.R., 12% in Krasnoyarsk Krai, 11.5% in Irkutsk Oblast. The forest resources of the Karelian A.S.S.R. constitute only 3%, and of Arkhangel'sk 8% of the total.

The forests are unevenly distributed over the territory of the Near North. The percentage of forest cover is high and, as already mentioned, amounts to 67.6%. The highest forest cover is found in parts of Irkutsk Oblast and Krasnoyarsk Krai, lying within the Near North zone. In these parts, forest cover reaches 84% and 82%.

Conifer species predominate in the Near North. They account for

80% of the forest-covered area. Only 20% of the area is under broadleaf species. The timber stand of conifer species amounts to 88%, and of broadleaf species 12%. The highest reserves (as a percentage of reserve forests of the Near North zone) of conifer species is found in the Yakut A.S.S.R. (20%), Irkutsk Oblast (12%), and Krasnoyarsk Krai (11%). The smallest reserves of conifers are found in Chita Oblast and in Karelian A.S.S.R. So far as broadleaf species are concerned, the highest percentage of the overall reserves of the Near North zone is found in the Tomsk (27%) and Tyumen (20%) oblasts.

In the forests of the Near North, mature and overmature stands predominate in the conifer forests. The highest percentage of mature and overmature stands is found in Komi A.S.S.R., Yakut A.S.S.R., Chita and Sakhalin oblasts, ranging from 80% to 88%.

The forests of the Near North are being unevenly utilized. The volume of logging on territories lying within the Near North zone amounts to approximately 92,000,000 m^3. The highest volume of logging is in the Karelian A.S.S.R. (18,000,000 m^3), Arkhangel'sk Oblast (25,000,000 m^3). In the forests of Tyumen Oblast falling within the Near North zone, only 5,700,000 m^3 are logged, while 4,700,000 m^3 are logged in Krasnoyarsk Krai. The volume of logging in the Khabarovsk Krai is even smaller at 2,400,000 m^3, and in Yakut A.S.S.R. slightly more than 1,000,000 m^3 are logged.

All the forests of the Near North zone are known, but they have been surveyed with a varying degree of accuracy (see Figure 1). Of the 317,000,000 ha of forest area, approximately 143,000,000 ha (45%) have been cruised mainly at III and IV standards of accuracy (as of 1971). The remaining forest territories have been surveyed by air-survey methods and visual studies from the air. On small territories in Komi A.S.S.R., Arkhangel'sk, Amur, and some other oblasts, inventories have been made.

All data verify that, within the Near North zone, huge and very valuable forest resources of the country are concentrated. A small proportion of them is being harvested, while the greater part requires further studies and surveying.

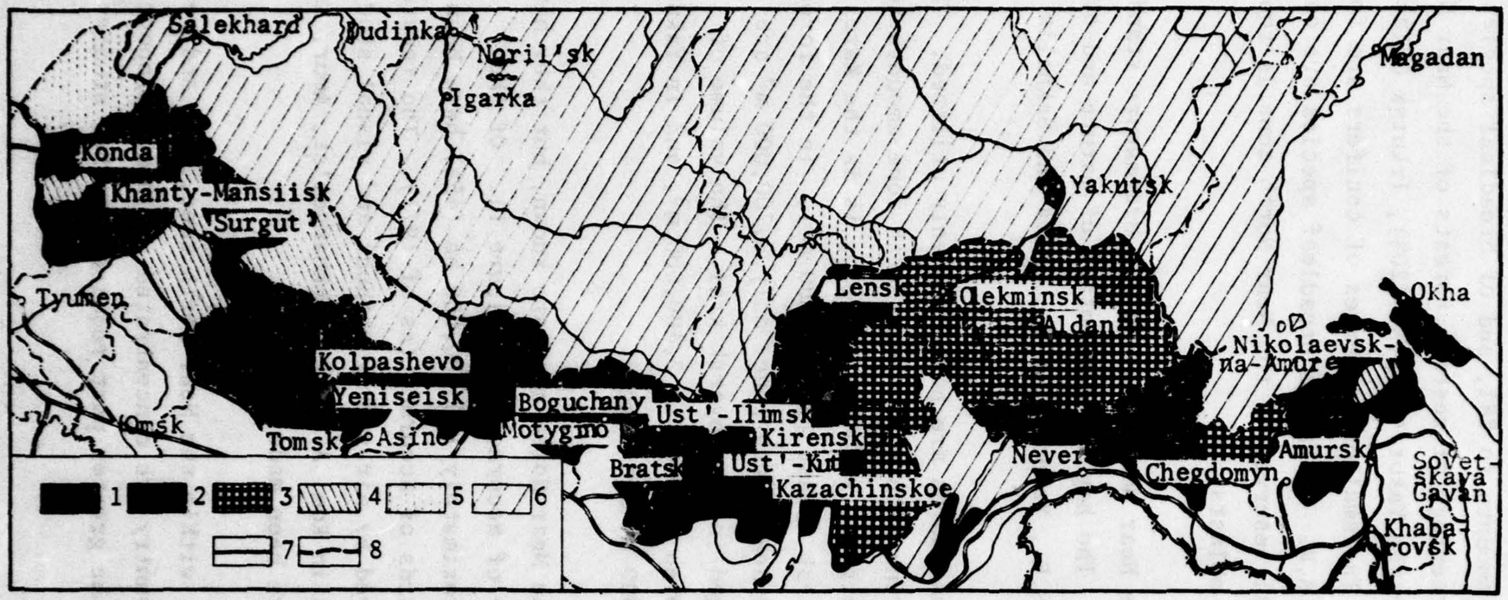

Fig. 1

The extent to which the forests of the northern Asiatic part of the U.S.S.R. have been studied

1 - cruised; 2 - cruised and surveyed from the air; 3 - surveyed from the air; 4 - cruised and studied visually from the air; 5 - air survey and visual study from the air; 6 - visual study from the air; 7 - southern limits of the northern zone; 8 - borderline between the Near and the Far North

Some prospects of industrial utilization of forest resources.

As we have seen from the above description, the forests of the northern zone under study are not outstanding in most cases for their quality. This is the result not only of severe climatic conditions but also of poorly-developed forest management measures, and also the fact that the accumulated reserves of mature and overmature stands have not been harvested. The natural processes of regeneration, in the majority of cases, are regulated to a very low degree. As a result, there is underutilization of the potential of the forest reserves, and this is over and above the annual losses of millions of cubic meters of wood which result from natural loss in overmature forests and from frequent fires.

Under such conditions, the opening of the forests by means of a gradual shift to the northern latitudes is dictated both by the need to log increasingly greater amounts of wood for the requirements of the national economy, and in order to change the forests of these regions gradually towards the trend of present-day intensive forest management, capable of utilizing the achievements of the most advanced forest-management science and of everyday practice. However, the solution of forest-management problems requires a correct assessment of the problems of the industrial utilization of the forests. It is essential, first of all, to consider carefully certain indices of the present-day state and the prospects of the industrial utilization of the forests.

The increase in the volume of logging in the northern regions, first of all in the regions of Siberia and the Far East, combined with organizing local industrial processing of as large a proportion of the wood logged as possible, has been during the years of Soviet power, the most important component of a programme for the development of the forest economy over a number of decades. But this programme has been particularly actively implemented in the last few years. In 1940, of the total volume of logging, amounting to 246,000,000 m^3, Siberia and the Far East accounted for only about 49,000,000 m^3. Of 118,000,000 m^3 of industrial wood logged, these regions accounted for 25,600,000 m^3, that is, 19.9% and 21.7% respectively. By 1970 the share of Siberia and the Far East in the overall volume of logging had risen to 31.9%, and for industrial wood to 32.7%. The forests of the Near North in Siberia and the Far East account for 7% of the overall logging in the U.S.S.R.

As already mentioned, the overall development and location of logging in the northern regions of the U.S.S.R. is determined by three main factors: 1) the growth of industrial processing of wood within the regions, 2) the constant need to supply those parts of the country deficient in forests with wood from the north, and 3) the development of exports of forest products.

In the European part of the U.S.S.R., in the coming years, only the Komi A.S.S.R. will meet all three requirements. The Arkhangel'sk Oblast, taking into account the conditions of internal processing of wood in the Oblast, as well as a certain increase in exports, will soon be compelled to refuse to supply wood to forest-deficient parts of the country. The forest oblasts of the Urals are in a similar situation. As for the regions of Siberia, the following data can be given to assess their possibilities.

The potential for expanding logging in the developed part of the forests of Western Siberia are represented by a relatively small area of larch (2,300,000 ha) and huge reserves of softwood-broadleaf species (17,000,000 ha). For the time being, their wide-scale utilization is difficult, particularly in Western Siberia, which has no available capacity for processing this kind of wood. Consequently, logging here must be expanded mainly by bringing under exploitation the pine and spruce stands of the newly-opened and reserve parts of the forest resources, and harvesting those stands of Siberian pine which are of no importance for nut-gathering. With the establishment of appropriate capacities and transportation facilities, these forest stands should make it possible to double or even treble the present volume of logging in Western Siberia within the next decade.

Eastern Siberia, despite the most intense development of industry, will not be able, even in the future, to limit the development of the forest industry and forest management to meet only local needs. It has been, and will continue to be, one of the most important wood-growing and wood-supplying regions for the country as a whole. It will be expected to meet the needs of the entire country for wood and wood products, and of Kazakhstan and Central Asia in particular.

As for the development of logging in the Far East, bearing in

mind the relatively limited local demand for wood, an issue of particular importance will be the wide possibilities of exporting round timber, pulp chips and various forest products to the countries of the Pacific Basin.

The bulk of wood in Siberia will continue to be processed locally into lumber, plywood, cardboard, paper, and wood boards, and so on. In 1975, according to approved plans, Siberia and the Far East will provide 34% of the overall volume of logging, 32% of lumber, 16% of plywood, 14% of wood-based boards, 20% of cardboard, and 15% of paper. In subsequent decades we can expect these percentage figures to increase still further.

The attained volumes of logging, and of the industrial processing of wood in Siberia and the Far East, are concentrated to a considerable degree in the Near North zone and in the adjoining forest territories.

When preparing long-range plans for the development of the forest industry using the forest resources of Siberia, and considering the issues of territorial organization of the industry, it is essential to take into account that within the zone of the Near North there are several groups of regions, each differing in the degree to which they have been developed, and each requiring development policies of different orientation.

Specifically, Siberian economists recommend singling out three groups of regions within the zone of Central Siberia: 1) the regions of stabilized forest utilization, where the reserves of mature stands of economically important species have to a considerable extent been exhausted and where continued logging should be subordinated to the goal of maintaining the optimum forest cover of the territory by limiting logging and restoring the stands by means of artificial and natural regeneration of forests. In this category must be placed, first of all, the regions adjoining the Trans-Siberian Railroad. 2) The regions of growing forest utilization, which are expected to provide the main bulk of the wood required for the next 15 to 20 years. Here can be included the forests which gravitate towards the Tavda - Sotnik railroad lines and toward the route of the future Tyumen - Tobol'sk - Surgut road, as well as the forest reserves in the basin of the Chulym River and on the left bank of the Ob River. 3) Regions to

be developed that will include those forests which are to become the main raw material base 15 to 20 years from now, and where in the next few years preparatory work should be initiated for future enterprises.

Obviously, there are no definite borderlines between the regions of the types specified above. In a number of cases it should be possible to accelerate the development of individual remote forest tracts without concern for the type to which the regions belong. But in such cases, complications will arise in providing an infrastructure for the logging industry. In a number of places where transportation facilities exist for taking the wood out (drifting, winter transportation over ice, and so on), logging should be organized by the expedition method, as recommended by one author as far back as 1966[1].

Such a method cannot be made obligatory for all. From this point of view, it is worth noting that the construction of new plants, recently planned for the wood-processing and for the pulp and paper industries, as well as the plan for the location of logging enterprises to serve them, is concerned with territories essentially classifiable in the majority of cases within the regions of the second type. For the time being, the proposed points must not be considered as final; nevertheless, they give a sufficiently clear picture of where, on what scale, and in which directions the industrial utilization of the forests of the Near North will develop.

Let us name some of the large-size forest industry complexes and enterprises which, according to the planning organizations of the forestry and pulp and paper industries, are to be located within the territory of the Near North[10].

Since the main consumer of products from future wood-processing complexes will be the regions of the European part of the U.S.S.R., of greatest interest in the immediate future will be the enterprises planned for construction in Tyumen Oblast. Among these are Surgut, Verkhne-Kondinskii (the upper Konda), and Nizhne-Obskii (the lower Ob) sawmilling and wood-processing combines, each with a production capacity of 300,000 m^3.

In Tomsk Oblast within the limits of the Near North, it is planned

to complete the construction of the Asinovo and Kolpashevo sawmilling and wood-processing combines, which will be of the same size.

In Western Siberia a number of pulp and paper combines and enterprises will appear. Some of them will operate in the vicinity of the sawmilling and wood-processing combines listed above (Kolpashevo, Surgut, Asinovo, and so on), but they will be subordinate to other administrative authorities.

In Eastern Siberia, railways have been built and more are under construction, which will make it possible to bring under exploitation large forest resources of the Near North. These lines are Achinsk - Abalakovo (completed), Reshety - Boguchany, and Khrebtovaya - Ust'-Ilim. In the vicinity of these railroads the volume of logging has reached 23,000,000 m^3. These areas can supply wood for the regional forest industry enterprises. Specifically, opportunities exist for building such large-scale complexes and enterprises as Boguchany, Yeniseisk, Kazachinskoe, Ust'-Ilim, Verkhne-Lenskii (upper Lena), and others, which are intended to produce large quantities of pulp, plywood, wood-based boards, and other products of intensive wood processing.

The projects listed above, although planned to make full use of the wood logged, will nevertheless not bring about a complete solution to the problem. Consequently, an important task for all designing and building enterprises engaged in the development of the forest industry of the region will be to ensure the real, complete, and fully-integrated utilization of wood taken out of the forests. In particular, in order to make use of low-grade wood and rejects, it will be necessary to plan for the construction of small enterprises in remote points which will produce pulp chips.

In Western and Eastern Siberia, as well as in the regions of the European U.S.S.R. lying within the Near North zone, the wood-processing industry of the future must include within its complexes a sufficiently large number of furniture enterprises located in zones which gravitate towards the densely populated regions and cities.

<u>How to utilize resources of the Siberian pine forests</u>. The forests of Siberia and the Far East contain enormous nonwood resources which can

yield many side-products. In this connection, it is important to consider the important problem of efficient utilization of the nut yields of the Siberian pine.

Of the overall area of Siberian pine stands, amounting to 37,300,000 ha approximately 12,000,000 ha are found in Western Siberia. Nearly all the remaining areas are located in Eastern Siberia and the Far East.

We may assume that the Siberian pine-covered areas were more or less the same or somewhat larger in the years prior to the First World War. But of course, Siberian pine nuts were harvested in relatively small areas. According to the available data, in 1899, 135,000 poods [or *2200.5 tons*]* of these nuts were transported on the Trans-Siberian Railroad. Four fifths of this was transported to the European part of Russia, especially to the Ural areas, and only a very small amount was exported. Siberian pine nuts were primarily loaded at railroad stations in Central Siberia, namely, Ob, Achinsk, Krasnoyarsk, Zaozernaya, Kansk, etc.(14).

On the eve of the *First World War the gross annual* harvest of Siberian pine nuts was 200,000 - 220,000 t. (Reference 7, p. 90). At the present time the harvest of these nuts is somewhat below that level. And yet, if the harvest could be raised at least to that level and Siberian pine nuts were processed to produce oil, this would provide a yield equivalent to that of a herd of 2 to 2.5 million cows. According to numerous available estimates, the possibilities of harvesting Siberian pine nuts in a number of oblasts in Siberia (Tomsk, Irkutsk, and so on) could, in years of average yield (which occur every 4 - 6 years) amount to 200 - 250 kg per ha, or on the average 50 kg per year. This points to the possibility of harvesting from the Siberian pine forests of our country a yield many times greater than has ever been achieved.

Of course, we must not forget that the production of Siberian pine nuts is still in many respects dependent on traditional customs, while

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* 1 pood = 16.3 kg.

other industries are supplied with powerful modern equipment, providing working conditions of a much higher standard and enjoying the benefit of day-to-day attention from government organizations. Furthermore, the harvesting of Siberian pine nuts coincides in time with the season of intense agricultural operations. Under such conditions, it is difficult to expect that a mass harvest of Siberian pine nuts could be organized. Nevertheless, we must not ignore the modest possibilities that there are, especially since the harvesting of nuts could be organized in conjunction with a number of other types of harvesting (sap-tapping, collection of mushrooms and medicinal herbs, etc.). From this point of view, probably of greatest economic interest are the Siberian pine forests of Tyumen Oblast (6,400,000 ha), Tomsk (3,000,000 ha), Irkutsk Krai (5,800,000 ha), Krasnoyarsk Krai (10,300,000 ha) and the Buryat A.S.S.R. (1,600,000 ha). Considerable portions of these Siberian pine forests are in the Near North, and consequently they are relatively more accessible for exploitation. Of lesser importance are the Siberian pine forests growing farther south, as for example, in the Altai Krai (948,000 ha), Omsk Oblast (127,000 ha), Novosibirsk Oblast (42,000 ha).

Unfortunately, the forest authorities do not yet have new, systematic data on the areas of Siberian pine stands located within the zones of developed and reserve forests of Siberia. But the nature and the degree of concentration of these stands can be seen from the data available in the SOPS [Council for the Study of Resources] section for forest resources, which give valuations for the resources of individual logging enterprises (see Table II).

The forest-covered area included in the data in the table covers 54% of the Siberian pine stands in the forests of the U.S.S.R., and consequently can serve sufficiently well as a basis for an overall evaluation of the resources. For example, Figure 2 shows the percentage of Siberian pine in the overall forests of Tomsk Oblast.

According to data available in the literature, in the seven oblasts listed above there are areas of Siberian pine with yields reaching 600 - 700 kg per ha in better years, and there have even been cases when these reached 1,500 - 2,000 kg. In the same years, Siberian pine in other territories had

Table II

Siberian pine areas in the forests of some oblasts of Siberia where Siberian pine occupies 10% or more of the overall forest-covered area (thous. ha)

Oblast/Krai	Number of forest industry enterprises	Total area of Siberian pine stands	Area of stands in forests of Group I	Of these	
				Mature and overmature	Maturing
Tyumen Oblast	9	6420	1048	898	128
Tomsk Oblast	27	2990	372	225	51
Krasnoyarsk Krai	20	10322	1663	1034	298
Irkutsk Oblast	18	5777	1717	1234	237
Chita Oblast	4	736	461	64	81
Buryat A.S.S.R.	11	1623	605	270	114
Khabarovsk Krai	7	1458	221	184	20

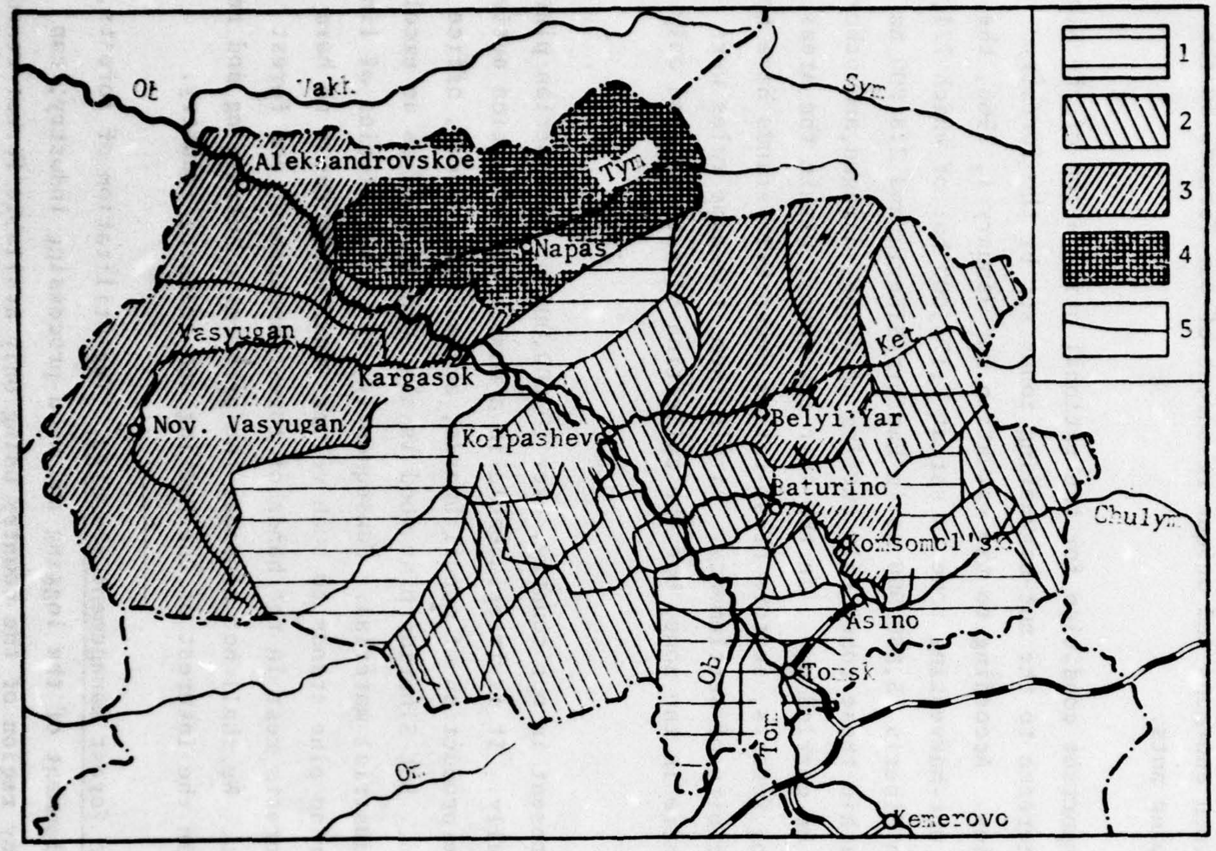

Fig. 2

The percentage of Siberian pine stands in the mature stands of the Tomsk Oblast (compiled by V. V. Sveshnikov)

1 - 10%; 2 - 20%; 3 - 30%; 4 - 40%; 5 - limits of the forests

poor yields. Consequently, only the expeditionary type of nut-harvesting with modern equipment can be efficient. At the same time, such equipment should represent no threat to the viability of the trees. It is understood that this proposal must be carefully studied and substantiated. In any event, we have no right to disregard such enormous and unique resources of our forests as the yields of Siberian pine nuts.

An important condition for the rational utilization of the Siberian pine is a strict adherence to the nut-harvesting zones set by the forestry management authorities. According to the valuation for January 1, 1966, the overall area of the nut-harvesting zone is set at 7,174,000 ha, of which 774,000 ha are found in Western Siberia, 5,880,000 ha in Eastern Siberia,and 218,000 ha in the Far East. Within these zones only cutting of dying, damaged,and other defective trees can be carried out. In the last few years, within the areas of the nut-harvesting forests, sectors of so-called Green Belt stands have been delimited in the vicinity of settlements. Within them, the same rules were introduced as elsewhere in the zone, but the collection of nuts is done only by kolkhozes.

At present in our country, over 10,000,000 m^3 of Siberian pine wood is logged annually. It is irreplaceable in a number of production activities, for example, for the production of pencil boards, accumulator veneer, office equipment, and so on. But Siberian pine wood is also widely used as an excellent construction and industrial material. Consequently, the possibilities of limiting the logging in Siberian pine stands to such volumes that would cause no harm to the Siberian pine forests rest in the hands of forest management and forest industry authorities. We shall not consider the problems of utilizing and restocking the fauna in the interest of the hunting and trapping industry.

Basic forest management measures. The utilization of forests, and in particular the development of the logging and wood-processing industry, can hardly be done in any region of the country using only available forest resources and relying on their natural regeneration. As already stated, the industrial utilization of forests assumes the introduction of a system of measures for regeneration, care, increase in productivity, and protective and preventive measures. The introduction of this set of measures is impossible without a

detailed evaluation and study of the forest resources available.

When studying and evaluating the forests of the northern regions of the country, and preparing proposals for their economic exploitation, there still persists a shortage of on-the-ground descriptions, although an overall evaluation of the forest resources of the country was essentially completed over ten years ago. Until recently the North was at that level of economic development which did not require a systematic study of the forests. Consequently, it is not surprising that the first description of the forest tracts of Siberia, dating to the last century, were done not by forest evaluators, but by travellers. Such descriptions are scattered through the reports of geographical, mining, ethnographic and other expeditions, and later on in the documents of the resettlement administration and so on. Of course, in our times these descriptions are of purely historial significance, but they are useful in that they allow us to see better the changes taking place at the present time. In this connection, when assessing to what extent the forests have been studied in the past (especially the forests of Siberia), one is forced to make use of the simplest information relating to the area and the forest stand.

The forest authorities and forest industry entrepreneurs of Russia started to become interested in the forests lying beyond the Ural Mountains, even within the limits of these greatly simplified criteria, only after they were traversed by the Trans-Siberian Railroad, and the resettlement movement was initiated.

According to data from studies carried out during the first decades of the twentieth century, it was determined that as of 1912 the entire forest area of Siberia and the Far East amounted to 346,300,000 desyatins or 378,000,000 ha, and of convenient forest area there were 135,000,000 desyatins, or 147,000,000 ha (Reference 11, p. 529). According to the data of the first valuation of forest resources of the country, done for October 1, 1927, the total area of forests of Siberia and the Far East amounted to 383,000,000 ha, of which the forest-covered area was 205,000,000 ha[13].

According to present data, within the territory of Western and

Eastern Siberia, even excluding kolkhoz and other allocated forests, there are 614,200,000 ha of forest areas, of which 503,000,000 ha are forest-covered.

It is clear that such a sharp difference is not the result of the physical increase in the forest areas, and that it only points to the fact that at that time knowledge of the forests was very imperfect.

As already pointed out, there are 317,000,000 ha of forests within the territory of the Near North which we have singled out. Of the above territory 143,000,000 ha have been cruised. Furthermore, the evaluation work has been done mainly at III and IV levels of accuracy. The remaining part of the territory has been studied using the methods of air survey and of visual evaluation from the air. These figures show very clearly that the northern forests have not yet been surveyed sufficiently well. Inadequate knowledge of the forests of these areas has resulted in an overestimation of the reserves attributed to them. Later, in the course of subsequent cruising, these have been corrected. The imprecision of the evaluation of the forests of Siberia and the Far East makes it impossible to pursue a correct forest-management policy.

In the next few years it will be essential to increase the volume of forest-cruising work, because the data from such cruising will be needed both for the determination of the extent to which the forests should be utilized and for the planning of forest management; it will also be essential for correctly locating the logging sites. Furthermore, it is imperative to increase the accuracy of valuations of forest stands by making wide use of measuring and conversion resource assessments, and through the introduction of better methods of compilation of forest resource data. As far as the little-known reserve forests are concerned, it now becomes necessary to increase the accuracy of the data relating to forest resources in these forests as well. For this, up-to-date methods of evaluation from the air should be used, combined with spectrozonal aerophotography, evaluational deciphering and studies on the ground.

It should be mentioned that the development of aerial survey methods, and their use in forest evaluation and forest study, results in increased

knowledge of the forests, of the composition of the stands and their quality, and also in the establishment of new patterns and functional linkages within the forest biogeocenoses.

As for the scientific research of forests, this is generally linked primarily with the problems of forest regeneration and with the increase in their productivity. However, under the conditions of forests only now being developed in Siberia, the link between the problems of increasing forest productivity and the evaluation of their resources appears in a somewhat different light.

The fact is that, as far as economic considerations are concerned, measures intended to result in an increase in the productivity of forests should always be carried out in a certain sequence guaranteeing first of all the utilization of the most accessible resources. In an extensive economic approach, relatively simple measures can have considerable effect on the yield of wood products. Among such measures can be classed, first of all, those for reducing wood-loss caused by forest fires or by damage from harmful insects or diseases.

In recent years, forest-management authorities and local soviet organizations have done tremendous work towards improving fire prevention in the forest area. A wide network of ground and air facilities for observing the condition of forests has been established; a system for preventing and fighting forest fires has been evolved. Nevertheless, forest fires still occur frequently in Siberia. Of particular danger to the forests is the spontaneous combustion of peat. Here is one fact of 100-year antiquity: "In 1869 a fire on Siberian peat grounds had terrible consequences. The large city of Yeniseisk could not cope with the advance of underground fire from all directions. In vain did the inhabitants dig a huge trench, hoping at least in this way to stop the progress of the fire. In the end they were still forced to flee the town, which was already enveloped in flames, by taking to the river. Several hundreds of unfortunate people perished" (Reference 6, p. 582). Even today, forests fires result in great losses of wood.

An important condition for increasing the economic efficiency of forest management within the zone under study is to switch to more advanced

systems and logging, for example, to abandon conventional-clear logging, which results in 30 - 40% of the stand being left on the site. Clear, concentrated logging in forests of different age composition should be replaced by a gradual-selective method, which would estimate losses arising from untimely logging of young and maturing stands.

Of ever-increasing importance, both in Siberia and in the European part of the U.S.S.R., is the full utilization of all the wood made available to logging enterprises for cutting, including low-grade wood, crown wood, damaged wood and so on.

According to available calculations, and the experience of leading workers, observing these very simple requirements can result, in many cases, in an increase in marketable wood per hectare of 100% and more. Furthermore, the gain could be achieved not in 20 - 30 years, which is the result of the usual forest-management measures directed towards increased productivity, but immediately at the very time when the forests are being harvested. And conversely, if such measures are not carried out, the effect of forest management will in fact remain unrealized. Consequently, in the immediate future, the struggle for high productivity of forests, or rather of the forest economy in the majority of regions of the North, first of all should consist of as full and as efficient as possible utilization of the forests which are being cut, at the same time ensuring their proper regeneration.

This does not mean, of course, that forest management and biological work in the forests, which are aimed at increasing their yield, should be abandoned.

The present state of knowledge of the problems of forest management and the forest industry in the regions of the North is such that in the majority of cases it does not allow for more than a postulation of the problems. And yet the present-day northern forests of the country are the foundation for the future highly-intensive forest economy in this zone of the country. The groundwork for this economy must be started right now. For this purpose it is necessary, first of all, to organize wide-scale integrated research in the zone of the Near

North, where the development of forests is taking place. It should proceed according to a single plan, so as to prepare in good time the scientific basis in this zone for a truly highly-intensive integrated forest economy of the future.

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TERRAIN FEATURES OF THE SUBARCTIC AND THE EFFECT OF INDUSTRIAL DEVELOPMENT

The Soviet Subarctic with its enormous reserves of natural resources is being developed at an accelerated rate (see "Problems of the North", issues 12, 13, 15, 16 and 17). In addition, the natural environment of the Subarctic possesses specific features which must be taken into consideration in the process of industrial development. The present article is devoted to ecological problems of the Subarctic associated with its industrialization.

The subarctic territories include the tundra, the wooded tundra, and the northern regions of the taiga. Here belongs the Murmansk Oblast, home of the Soviet Union's main base for the production of phosphate raw material for the fertilizer industry, an important base for the nonferrous metallurgical industry and the extraction of mica and rare elements, as well as a centre of the fishing industry. The subarctic includes: the Pechora Coal Basin, which supplies valuable coking coal for the ferrous metallurgical industry in the Northwest and Central regions of the European part of the U.S.S.R., the northern part of the Timan-Pechora oil and gas region; the largest region of the country's developing gas industry, in the Yamalo-Nenetskii National Okrug, and the largest region of the country's nonferrous metallurgical industry in the Noril'sk raion; and vast gold and tin-mining regions on the Yana River and in the Chukchi National Okrug. The land mass and continental shelf of the Arctic and Subarctic contain enormous potential mineral raw material resources. This is a highly promising region for industrial development and it is, therefore, of great importance, from the point of view of the national economy, to take into consideration the features of its natural

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environment.

A great deal is already known about the environmental peculiarities of these regions. The subarctic terrain is distinguished by the exceptional non-uniformity of its soil-subsoil complex, the most energy-intensive and functional layer of the lithosphere. The lower limit of the biosphere throughout most of the Subarctic coincides with the permanently frozen base of the seasonally thawing layer.

As we know, the stability of an ecosystem (biogeocoenosis, geosystem, terrain, natural complex) is determined by the stability of its components: the lithogenic base or soil and subsoil, phytocoenosis, and zoocoenosis, which in turn are the simpler self-regulating systems which make up an ecosystem.

The disequilibrium of the subarctic soil structure is one of the main reasons for the instability and vulnerability of the ecosystems of this region. Changes in the underlying surface, which cannot be avoided in industrial development, result in disturbance of the heat exchange between the soil and the atmosphere, thus causing the frozen ground to thaw, subsidence and collapse of the surface, the formation of thermokarst and mud ravines, lakes, solifluction streams, etc.

Disturbances of the soil and vegetation cover, and silting, etc., which are unavoidable with industrial development, are superimposed on these processes in the Subarctic (see Figure).

In drawing attention to the importance of parameters of the state of the soil and subsoil and the surface air, such as temperature, humidity, ice content, and to the importance of the energy resources which lie behind the physical and biological processes in these media, we should take into consideration the special significance of certain factors relating to the rate of development of northern terrain. These include temperature and moisture rates of variation in time and space (gradients), density of descending (positive) and ascending (negative) heat flows at different times of the year, the frequency and amplitude

Fig.

Flower-bedlike microrelief formed during thermokarst process in an area with vein ice deposits after removal of sod and vegetation cover

of the temperature fluctuations of the soil and subsoil, and the increase in the depth of soil thawing and freezing over a number of years.

The need to consider factors relating to the rate of development of Subarctic terrain will be examined in the example of thermokarst. The value of the two extensive factors: the radiation balance of the active layer* and the thickness of the seasonally thawing layer, all other things (composition, structure, and the physical properties of the soil and vegetation) being equal, decrease from south to north, whereas the density of the descending heat flows in the spring and summer and the increase in the thickness of the seasonally thawing layer at half periods of the warming trend of short-term (5 - 6 year) variations in the annual weather regimes increase in the same direction. Thus, for example,

* According to A.I. Voeikov[3], the outer active layer is the topmost layer of soil with its vegetation and snow cover, pools and films of water, which receives, reflects and accumulates solar energy, radiates and gives up convection heat to the atmosphere, soil and subsoil.

the silty clay soil of the Yana-Indigirka coastal plain (71^{o}N) receives 150,000 kcal of heat per m^2 in the spring and summer, whereas the same soil at Skovorodino Station on the Amur Railway (54^{o}N) receives only 60,000 kcal/m^2, i.e., 2½ times less.

As a result of this, all other things being equal, thermokarst in the tundra, wooded tundra, and northern taiga develops more rapidly than in the middle and southern taiga[20]. In addition to an increase in the heat flow density in the spring and summer seasons as we travel northward, the frequency and amplitude of the short-term temperature flunctuations of the active layer and the surface air increase.

Firm confirmation of this is provided by the so-called "dead" railway in the north of West Siberia, which runs east from Salekhard to the Pravaya Kheta River.

All the changes which occurred here can be combined into several groups[9]: 1) disturbance or destruction of the soil and vegetation cover and exposure of the mineral subsoil in a band several hundred metres in width; 2) tree felling; 3) changes in the relief, such as excavations, trenches, cuttings, embankments, earth mounds, etc.These have altered the heat exchange between the soil and the atmosphere (in the summer on account of the disturbance of the soil surface, and in the winter on account of the redistribution of snow), and have disrupted the drainage and hydrothermal regime of the soil and subsoil.

As a result, during the 1949-1953 period (when the railway was being built) and during subsequent years, 1) thermokarst lakes and pits appeared; 2) in places where embankments had been erected, barrier (not thermokarst) lakes appeared, under which taliks began to form; 3) underneath the embankments the permafrost table rose between 0.5 and 1.0 m, causing additional ponding; 4) in places where, as a result of the absence of tree-shrub vegetation the snow had begun to blow away, ground freezing intensified, i.e., the temperature dropped and the thickness of the frozen ground increased; 5) the piles of bridges, etc.

heaved upwards out of the ground.*

Construction under conditions in which permafrost and high-temperature (close to $0^{o}C$) frozen masses occur in island-like formations is entirely feasible. First of all, it is necessary to carry out a detailed engineering-geological permafrost survey including precise determination and charting of the soil lithology, temperature, ice content, etc. Knowing the nature of the soil, it is possible to determine measures for the prevention of undesirable consequences. The wide experience gained by Soviet experts in the field of permafrost construction is recorded in instruction manuals. Unfortunately, construction and transport workers do not always follow these instructions.

In the construction of permanent and major installations on frozen and thawing soil it is essential to use methods of ensuring the stability of the main structural components recommended by permafrost engineers[11,15].

Experience gained in the construction of roads and buildings on permafrost indicates that the changes which occur in subarctic ecosystems on frozen ground when certain components are disturbed are fundamentally different from those which occur in ecosystems in the temperate zone (when subjected to similar disturbances) on account of the nonuniformity of the soil and subsoil in the Subarctic.

Man's economic activities are having an increasingly greater effect, not only on the upper permafrost layers, but also on deep layers, tens and hundreds of meters below the surface. Boreholes reveal tectonic fractures containing deep pressurized water. Moving through the boreholes at different depths, ground and surface water can cause extensive underground degradation and melting of the frozen strata. The force and speed of these phenomena correspond to natural processes extending over whole epochs.

Boreholes open up new paths for the movement of gases in frozen

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* This is described in greater detail in a book by one of the authors of this article[9].

ground. Gas deposits shield the flow of heat from deep inside the earth, which results in a thicker stratum of frozen ground. This effect is further amplified if the gas deposit is ruptured, thus causing adiabatic expansion of the gas and a drop in the temperature of the surrounding rock[1].

Besides degradation, cases of aggradation of the permafrost have been noted as well, for example, near Vorkuta. This city is located in the shrub tundra subzone. The temperature of the frozen soil in its environs is close to $0^{o}C$, i.e., it is unstable. The seasonally thawing layer is approximately 1 - 2 m thick, sometimes more; taliks are encountered. Shrubs (yerniks, i.e., dwarf birch and willow stands) play a large part in keeping the temperature close to $0^{o}C$ by holding the snow, thus protecting the ground from intensive freezing. The shrubs are cleared away for agricultural development and the arable land remains bare for the winter; what snow there is affords it scant protection.

Under these conditions the temperature of the frozen ground begins to drop, the thickness of the seasonally thawing layer is reduced, thus affecting the crops. Permafrost begins to appear in places where there were taliks, and plants which formerly flourished here no longer mature.

The recultivation of land damaged by thermokarst is practically impossible, since here there is no borrow soil to fill the holes formed by the melting ice.

It has been established that subterranean ice deposits occur widely in the Yana-Indigirka and Kolyma lowlands, on the Novosibirsk Islands, in the Lena Delta, and in the Anabar-Olenek and Lena-Vilyui lowlands. It has been calculated that if the subsoil of these lowland regions thawed to a depth of 50 - 100 m (and it is at these depths that ice accounts for at least 50 - 60% of the total volume of the soil), the land would then sink below sea level[19]. This would be catastrophic because these regions contain large reserves of placer gold, oil, and gas, and they provide good reindeer pasturage.

It follows from what has been said above that development which causes minimum or no damage to the soil structure, depending on the ice content, is one of the main ecological and technological problems in the Subarctic.

The possible effect of industrialization on the active layer and the surface air layer. Until now it had been thought that the local climate changes as a result of the direct effect of people on the surface air during the industrial development of a given area. In fact the local effects of industrial centres on the troposphere does not result in any noticeable changes in the local climate - the levelling effect of the general and regional atmospheric circulation is too great.

Again, A.I. Voeikov[3] noted that the local climate can be transformed in the desired direction only by means of a change in the thermo- and hydrophysical properties of the active layer. This principle is now widely accepted by geocryologists.

By influencing the composition, structure and properties of the active layer over large areas man changes not only the climate, but the hydrothermal regime of an entire stratum of the earth's crust together with the annual and perennial hydrological cycles. In northern regions, where the subsoil is frozen, a major variation of the properties of the active layer and disturbance of the heat balance of the soil usually entails disturbance of the mechanical balance. This is not observed in the temperate zone with its thin seasonally freezing layer, since here neither the freezing point of water nor the melting point of ice comes within the range of the subsoil temperature variations.

In the North there is snow on the ground from the middle of September or beginning of October until June. During this time less than 25 - 30% of the incoming global radiation is absorbed. In industrial centres and their environs (Murmansk, Monchegorsk, Apatity, Kirovsk, Vorkuta, Noril'sk and Magadan), and along the railroads and highways the snow is covered with a considerable quantity of dust, which reduces its albedo and causes more rapid melting. The lengthening of the snowless season in such areas varies from one or two weeks to one or one and a half months. These areas are usually covered with asphalt, sand, or gravel and, therefore, essentially heat is not expended on moisture evaporation, but on heating the cover and underlying soil. According to our observations, the summer air temperature in Vorkuta and Noril'sk is 1 - 2° higher than in the surrounding tundra and

sparse forest. The soil temperature is 2 - 6° higher. The summer thaw in the towns is, therefore, several times more intensive than it is in the outskirts. The built-up, industrially developed areas are very small by comparison with the vast expanses of tundra and sparse forest. Their influence on the surrounding terrain is slight: it is limited to an area two, more rarely four or five times that of the industrial site. If large areas are subject to dust contamination as a result of industrial development and the albedo is altered, this could possibly lead to considerable changes in the heat balance of the active layer, the thickness of the seasonally thawing layer and the conditions of its equilibrium.

As we know, an increase in dust and smoke pollution reduces the atmospheric transmittance, which in turn reduces the illumination and ultraviolet radiation intensity to 40 - 50%[2]. The dust content of the atmosphere can have a greater effect in the Arctic and Subarctic because of the low station of the sun and the fact that the sun's rays pass through a longer path in the lower atmospheric layers. Since, even without this, the amount of ultraviolet radiation in the Subarctic is small, a further reduction is unacceptable.

Industrial, administrative, and residential buildings in the North have to be heated all, or nearly all the year round. Therefore, there is considerably more waste per unit of industrial and residential space than in southern regions. Moreover, the harmful substances in the polluted atmosphere under northern conditions have a much greater effect on organisms than in the south. The possibility of self-purification of the air in the North is far less than it is in any other zone because of the short vegetation period, the small phytomass, and the limited number of sunny days. During periods of high atmospheric humidity and fog (which are characteristic of the North) the sulphur dioxide may react with the moisture and form sulphuric acid vapour. This vapour is dangerous to humans, animals and plants and causes corrosion of steel. Under such conditions carbon dioxide, reacting with water, forms carbonic acid, which attacks limestone and other materials.

Atmospheric pollution in the North is especially destructive on account of the specific nature of the bioclimatic conditions. This danger is

directly proportional to the number of days with anticyclonal weather. At present there are few industrial centres in the Far North and the air in subarctic towns is reasonably clean. At the same time a knowledge of the specific nature of the bioclimate will facilitate the proper location of industrial centres and the elaboration of measures to prevent air pollution.

The most radical method of combating air pollution is the conversion of plants to a closed air cycle technology. This can be extremely effective. The dust collected by the air-purification systems is high-grade raw material. The use of such a system at the arctic "Apatit" Combine provides raw material for fertilizer production. Used on a large scale, closed cycle air purification plants could save millions of rubles annually. They produce an air flow which contains only one fifth of the mechanical impurities normally found in country air. Clean air reduces the incidence of sickness among workers. Apart from this, such plants can produce hot air, which is then used for heating purposes at the same time, thus affording additional substantial savings. As reported in "Pravda" on 24 February, 1971, the outlay on such installations is recovered very rapidly - within eighteen months to two years.

The problem of preventing the pollution of water bodies. The literature on the North abounds with references to its practically unlimited water resources, which ostensibly create favourable conditions for the purification of industrial effluent. We cannot agree with this. It is essential to take into account the fact that surface water in the North consists of rain and snow; it is weakly mineralized, contains large quantities of organic matter (hence its brownish colour), the oxidation of which consumes a great deal of oxygen. Even without this the waters of northern lakes and rivers would be weakly saturated with oxygen, especially during the winter. The longer the lakes and rivers remain frozen, the poorer the quality of the water, since in this state oxygen enrichment is impossible. As we know, oxygen insufficiency is the principal cause of fish kill in northern lakes and rivers.

As early as 1877 I.S. Polyakov wrote: "Along the entire lower course of the Ob the water begins to redden in winter; then it has an unpleasant taste and

it bubbles. The water "dies" earliest at Obdorsk and Polui, where even water from the ice has a bitter taste. Therefore, in the winter the inhabitants of Obdorsk travel several versts* from the village along the Ob for ice" (Reference 5, p. 30). And that was almost a hundred years ago.

With the growth of industry the discharge of liquid waste into northern rivers is increasing. In rare cases industrial effluent is purified in the rivers themselves, but that is only where there is an abundance of dissolved oxygen in the water. In the temperate belt river water can purify itself over a distance of 200 - 300 km. Under northern conditions there is little self-purification even over distances of 1,500 - 2,000 km[5].

Oil, as we know, is one of the most intensive water pollutants. Therefore, the development of oil and gas fields necessitates the careful elaboration of measures to combat the pollution of rivers and their tributaries. Another reason for such preventive measures is that little is known about the ways in which oil products are transformed in water bodies. We know that they are not readily soluble and that oil decomposes slowly, especially at low temperatures. Oxygen is needed for this process. The complete oxidation of oil under aerobic conditions takes at least 100 - 150 days. The decomposition of oil under anaerobic conditions takes even longer.

Thus, the self-purification potential of northern lakes and rivers is very limited, a fact which should be taken into account in the development of the Subarctic.

Under conditions prevailing in the southern zones of the temperate belt 75 - 90% of the domestic drinking and industrial water requirements are satisfied by surface water[5]. Ground water is plentiful. In the North, however, surface water is much more valuable, since here there is little free ground water. It is impossible to permit the pollution of rivers on which towns and settlements are situated, since this would increase the concentration of nitrates, nitrites and ammonium sulphate[4]. There is a need here for resolute organizational measures and the dissemination of information to people who come to work in the

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*"versta" = 3,500 feet (Transl. Ed.)

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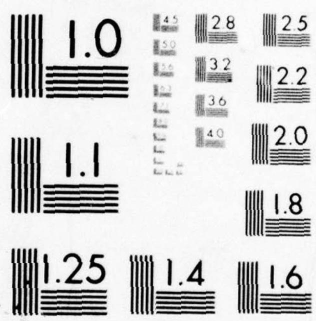

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

development of the oil industry. We must strive for the conversion of our industrial plants to circulating, closed water supply systems, so that the discharge of industrial waste into water bodies is entirely eliminated. This applies not only to enterprises in the Arctic and Subarctic, indeed it applies in greater measure to enterprises in large industrially developed cities, like Omsk, Novosibirsk, Tomsk, Tyumen, etc., which are situated on northward-flowing rivers.

Some experts recommend that urban sewage be used for the irrigation of crop fields. In the first place, this improves the economy of irrigated crops; and, in the second place, soil is the most effective agent for rendering sewage harmless. These recommendations are not restricted to southern zones. The soil layer in the Arctic and Subarctic is thin (30 - 150 cm in depth) and very cold. Even in July, at a depth of 20 cm the temperature rarely exceeds 5 - 10°C. Remember that at this time of the year the temperature of the soil near Moscow is between 18 and 20° C. The speed of chemical reactions, as we know, depends on the temperature (van't Hoff's law). Moreover, the frozen subsoil, which in the summer is located at a depth of 50 - 100 cm, acts as an impervious horizon. Thus, the recommendations proposed for the central and southern zones of the country are not acceptable in northern territories. The question of how to dispose of domestic waste in the North has still not been studied sufficiently.

<u>Questions relating to the construction of large hydroelectric power stations on northern rivers</u>. It has been calculated that approximately 88% of the water resources of the U.S.S.R. are located in sparsely populated regions of the North, and in those regions where the bulk of the population lives, where the industrial might of the country is concentrated, and which include all the irrigated land, river discharge accounts for only 12% of the country's total water balance. In this connection there are plans to construct large hydroelectric power stations with enormous reservoirs on the lower reaches of the Ob, Yenisei, and Lena. We are all familiar with the Lower Ob hydroelectric power project with its 30 m high dam and an output of approximately 5,000,000 kw. The large amount of research work that has been conducted in connection with this project was used as the basis for conclusions and forecasts on the influence of a large reservoir on the natural environment of the North. These conclusions and forecasts are wholly applicable to other similar projects which might be undertaken on the Lower Yenisei and Ob. Let us consider them.

According to the plan the area of the Ob reservoir may reach approximately 60,000 km^2. According to the calculations of V.S. Mezentsev and V.M. Shirokov (1970), a 30 m high dam will mean the flooding and swamping of at least an additional 50,000 - 65,000 km^2 of land, the complete loss of the timber stand, and other consequences. The construction of hydroelectric power stations on large Siberian rivers in lowland terrain conditions will create enormous reservoirs, covered with ice for at least 8 - 9 months of the year, and vast expanses of swampland.

The ice on such vast reservoirs would break up 20 - 40 days later than at present, owing to the fact that there would be no mechanical breakup of the ice cover, which at present accompanies the movement of the flood water from the south. Owing to the high loss of solar heat due to the increased albedo together with the heat loss attributable to warming the ice and evaporation, we can expect lower summer temperatures in the vicinity of the reservoir.

It will be recalled that Hudson Bay, which cuts deeply into the Canadian land mass, determines the artic climate and the treeless state of the tundra as far south as the latitude of Moscow. Here the subarctic wooded tundra extends almost to 50^{o}N, i.e., the same latitude as Khar'kov and Karaganda.

In the opinion of ichthyologists[13], the construction of the Lower Ob hydroelectric power station would seriously damage the fishing industry in the Ob-Irtysh Basin. At present this basin yields approximately 700,000 centners of high-grade fish annually. These catches can be increased to 1,000,000 centners a year. However, in the event of a dam being constructed, sturgeon, nelma, and other fish will be prevented from reaching their spawning grounds in the Upper Ob and Irtysh and these species will virtually disappear from the catch. The biochemical decomposition of submerged vegetation will reduce the amount of oxygen in the reservoir and thus add to the fish kill.

The list of consequences can be extended still further: higher costs for exploration and development of oil and gas fields and for timber logging; reduction of game animals; stronger winds; adverse effects on navigation conditions,

etc. Further work on the dam project has been halted for the present.

As mentioned above, these conclusions and forecasts also apply in every respect to possible super-giant reservoirs in the lower reaches of other Siberian rivers[8,9,10].

To avoid creating conditions which would result in deterioration of the climate and the environment, subarctic hydroelectric stations should be constructed in mountain regions. There are many successful examples of this: the hydroelectric power stations in the northern part of the Kola Peninsula, the Ust'-Khantaika, and, finally, the Kolyma, now under construction, which will have the largest installed capacity of any hydroelectric power station in the North. Similar power stations could be constructed on the Central Siberian Plateau, particularly on the right-hand tributaries of the Yenisei in the mountainous regions of Yakut A.S.S.R. and Magadan Oblast. Plans for several of these are already in hand.

The effect of industrial development on the vegetation cover. The vegetation cover is subjected to very severe changes as a result of industrial development. We have already remarked on the fact that the stability of the ecological systems is determined by the stability of their components, i.e., subsystems, and, in particular, plant communities. Subarctic phytocoenoses are very unstable and can be destroyed quite easily. This is due not only to the nonuniformity of the soil and subsoil referred to earlier, but also the fact that many of the higher plants (trees, shrubs, and forbs) are close to their climatic limits and, particularly in the case of lichens, are very sensitive to pollution.

It has been established that trees, shrubs, lichens, and mosses are affected by: sulpher dioxide, ammonia, fluorine compounds, fumes of asphalt, tar and certain acids produced by the incomplete combustion of gasoline and oil, and in general by industrial dust, which contains chemically active substances. Bushy lichen, which serves as food for domestic reindeer, is particularly sensitive to air pollution. The atmosphere can be polluted by sulphur

dioxide produced in the burning of oil and gas. This causes the loss of chlorophyl in lichens followed by the withering away of the thallus and its separation from the substratum. Some lichens become sterile. In a number of countries the purity of the atmospheric air is judged by the presence of lichens.

The precipitation of chemically-active matter on the surface and its percolation into the soil reduces the already low level of activity of soil bacteria and increases the soil acidity.

Spruce, pine, fir, larch, alder, willow and birch, in that order, are sensitive to soil and air pollution. In providing municipal parks and green belts in the North stress should be laid on broadleaf species which, incidentally, trap considerably more dust than conifers.

Dust precipitation and general contamination of the active layer and surface air also inhibit mosses, retarding or stopping their growth, depending on the degree of contamination. Trampling has the same effect, and it is for this reason that the moss cover in the immediate vicinity of towns degenerates. Moss is a good thermal insulator and its destruction increases the warming and thawing of the soil, which results in degradation of the tundra phytocoenosis and the entire ecosystem. Where moss is trampled or burnt in the wooded tundra or the northern taiga, grasses, willow herb, and deciduous species of undergrowth, mainly birch and aspen, appear. Then begins an intensive rearrangement of the existing interrelationships in the ecosystem and degradation of the primary ecosystem. A similar event in the East-European North, with its high-temperature permafrost, could lead to the complete thawing of the frozen ground. If an ecological service (topographical or geographical - something like the forest management service) were created, such processes could be controlled and directed as required*.

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* Research and planning organizations concerned with gas pipeline surveys in the North have long been recommending the setting up of permafrost stations for observations of changes in soil conditions on gas pipeline routes. This is commendable, but such services should not be restricted to gas pipelines; they should be set up as a matter of course around industrial centres.

The economic activities of man in the North are manifested in the state of the vegetation cover, and it is difficult to define the boundary between the influence of economic activity in general (reindeer husbandry and the trampling of pastures, hunting and fishing) and purely industrial effects. The effect of industrial development began to tell, not on virginal nature, but against a background of vegetation already changed by man. Thus, for example, lichen pasturage is diminishing, irrespective of industrial development. The same can be said of the northern forest boundary. It has been established by investigations that the northern forest boundaries are at present located 100 - 200 km south of possible climatic limits. This southern tundra belt, where the minimum of heat required for the growth and development of trees is present, but not the trees themselves, we have designated the relatively treeless tundra belt[7,8,9]. A significant role in its formation was played by man as a consequence of fires, trampling, the grazing of reindeer herds, logging, etc.

The retreat of the forest boundary to the south has an adverse effect on the environment: on newly formed tundralike areas the winds are stronger, the snow cover is reduced and compacted, the soil freezes more intensively, the temperature of the seasonally thawing layer drops and, at the same time, its thickness increases, thermokarst pits and depressions appear, all of which make it extremely difficult for trees to seed and grow in such places. There is no regrowth of forest vegetation here, because changes in the vegetation are accompanied by changes in a whole complex of interconnections in the environment. Human life in such places becomes more complex and difficult. Trees and shrubs perish primarily in the vicinity of inhabited localities and along roads - where they are needed most.

At the present time northern industrial centres are, as it were niches, around which the tundra cuts southwards for many kilometers into the sparse forest zone. This is a consequence, not so much of the direct influence

of industrialization, as of ill-considered actions (due to ignorance) on the part of man, involving tree-felling and fires. In northern industrial centres and their environs air and soil temperatures rise, the snow-free and growth periods lengthen, and the winds moderate; in other words, ideal thermal conditions are created for tree and shrub vegetation. All this favours the planting of trees and shrubs, not only in towns and settlements, but also around them, i.e., provides the prerequisites for creating a green belt around northern industrial centres. Unfortunately, to date, hardly any use has been made of this possibility.

In Vorkuta, workers of the Urban Department of Municipal Services have planted several hectares of basket willow, which has a high toleration of air and soil pollution. In addition to basket willow and birch, the municipal nursery contains several hundred specimens of Siberian spruce. Attempts to create tree belts along the tundra and wooded tundra sectors of the railway are meeting with some success. It has been found that an 80 m wide multirow snow-protective tree belt 1 km long, with subsequent attention at five-yearly intervals, is five times cheaper than 1 km of snow fencing and, moreover, tree plantings are more effective against snowdrifts than fencing.

It appears that Siberian and Daurian larch, the hardiest and more durable northern tree varieties, may take root in the East-European North. Snow will accumulate in the plantations, insulating the soil during the winter and facilitating rapid melting in the spring, thus promoting higher soil temperatures and an increase in the thickness of the seasonally thawing layer. Experience shows that, in time, forest birds appear in the thickets. Tree belts will create a favourable microclimate in the fields of suburban farms where certain vegetables and meadow crops are grown.

This improved heat potential afforded by industrial centres is also utilized to some extent in Noril'sk and Magadan, where trees are also planted in the city.

Thus, along with the negative effect it has on trees and shrubs, industrial development also creates the preconditions for pushing the limits of these plants tens of kilometers farther north. Air and water pollution (the

principal adverse factors affecting vegetation) can be reduced to a minimum, tree-felling stopped and fires eliminated. In theory this is entirely feasible: industrial development need not depress the moss and lichen vegetation and could facilitate the growth of trees and shrubs. Tree stands could be established in the relatively treeless tundra belt. Meanwhile, the size of this belt is increasing[8,9]. Unfortunately, for all the obviousness of the harm caused as a result of the destruction of arboreal vegetation and the benefits afforded by forest vegetation in the North, not a single research organization connected with town planning and construction is concerned with questions relating to its preservation and development. We support the proposal put forward by Irkutsk research workers (geographers and biologists) concerning the introduction of legislation to ensure that protective afforestation measures are carried out during any construction work in the North[14].

Thus, we see that there are objective premises indicating that industrial development in the North can contribute to the improvement of environmental conditions. The realization of these possibilities entails research, experimentation, and the practical application of the resulting conclusion.

<u>The animal kingdom</u>. Industrial development in the North is concentrated in centres, thus leaving vast areas untouched, a fact which facilitates wildlife protection. This means that a radical alteration of the natural environment (as in the steppes, for example) associated with northern development, does not yet pose a threat to animal life. However, in many places the members of geological, topographical and other expeditions engage in uncontrolled hunting activities.

One of the possible ways of making rational use of northern animal resources is to organize strictly controlled hunting and fishing holidays. This would also be facilitated by the following process. In the past few decades animals have been moving from the forest zone into the tundra. Moose, pine martens, otters, red foxes (which, incidentally, drive arctic foxes out and occupy their dens) have begun to appear in the southern tundra. Brown bears have also been seen here. It is hardly possible to attribute this to the warming trend in the North, since this came to an end in the late 1940s and early 1950s, while the movement of forest animals into the tundra is still continuing. The economic

activities of man, which force the animals out of the more southerly zones, is by no means an unimportant factor in this northward movement.

Zapovedniki and zakazniki.* The industrial development of the North requires the expansion of conservation areas - zapovedniki and zakazniki. On a map showing the allocation of zapovedniki(6) it is evident that two thirds of them are in the European part of the Soviet Union, about 15 in the Central Asian republics, and several in the Far East. In all the vast expanse of the Asiatic part of the U.S.S.R. there is not a single zapovednik - from the Urals to the Pacific (with the exception of the Kronotskii zapovedniki on the east coast of Kamchatka) and from the shores of the Arctic Ocean, south for over a thousand kilometers, to the latitude of Krasnoyarsk (the "Stolby" zapovednik).

It is expedient to organize zapovedniki and zakazniki in each of the physico-geographical provinces of the North, from Northern Kola in the west to Chukotka in the east. The zapovedniki will serve as standards of the natural environment of the physico-geographical provinces. Already Northern Kola has two - the Kandalaksha and the Lapland zapovedniki. There is also a need for one in the East-European North, where coal is being mined and large oil and gas reserves have been discovered. The physico-geographical conditions of this province are markedly different from those on the Kola Peninsula: the climate here is harsher, the soil temperature is negative, in a number of places close to $0^{\circ}C$; the frozen ground degradates, a fact which affects the dynamics of the northern forest boundary. This zapovednik should have a north-south direction, from wooded tundra to tundra. It would be expedient to allocate territory for the zapovednik from the settlement of Khoseda-Khard (on the northern tree line) in a northerly direction towards a forest island surrounded by tundra in the middle reaches of the More-Yu River. Thus, this zapovednik would be situated between 58 and $60^{\circ}E$ and include wooded tundra, southern tundra, and a unique forest island surrounded by tundra on the More-Yu River. The Nentsy consider this forest island sacred, a forbidden area visisted by them only in connection with the death of a kinsman. Disturbance of the natural environment here is minimal.

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* See Glossary. (Transl. Ed.)

In Western Siberia it would be expedient to create a zapovednik on the Yamal Peninsula (see the article by V.V. Kryuchkov in this issue of "Problems of the North").

In the central part of Central Siberia the habitat of the most northerly and largest herd of wild reindeer, the world's most northerly forest areas (in the basin of the Lukunskaya River(8,9)), and the forest islet of Ary-Mas on the Novaya River should be protected. Both rivers empty into the Khatanga: the Lukunskaya from the right and the Novaya from the left.

Research workers at the Institute of Biology, Yakutsk Branch of the Siberian Department of the Academy of Sciences, U.S.S.R. propose the setting up of three zapovedniki in Yakutiya: the Tundra zapovednik on the lower reaches of the Indigirka; the Verkhoyansk zapovednik slightly north of the 64th parallel; and the Southern Yakutian zapovednik.

As for the Far-Northeastern Asia, it would be best to establish the Chukchi zapovednik in the Amguema River Valley.

In addition to composite zapovedniki, it is necessary to establish zakazniki to preserve the expanding range of the eider duck, common to Kolguev Island, Novaya Zemlya and Vaigach Island; and other aquatic birds in every physico-geographical province, especially in the lower reaches of large rivers.

We have already referred to the fact that throughout most of the Far North, under the influence of man, the northern forest boundary is actually retreating to the south and in its place are stronger winds, and lower air and soil temperatures. Therefore, in accordance with the Resolution of the Council of Ministers of the R.S.F.S.R. "On the establishment of protected zones in the northern part of the forest belt" (of 16 May, 1959)* it is expedient now to raise the question of establishing "zakaznik" conditions in this protecting forest belt adjacent to the tundra.**

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* "Okhrana prirody - sbornik zakonodatel'nykh aktov" (Nature conservation - a collection of legal docments). Moscow, Yurizdat, 1961, p.90.

** This question was raised by one of the authors at a meeting of the Presidium of the Academy of Sciences of the U.S.S.R. during a discussion of the question "The biological resources of the lands of the Far North" in April 1972 (see "Vestnik AN SSSR", 1972, No.9, pp. 5-9).

In the Subarctic the problem of the relationship between people equipped with modern technology on the one hand and nature on the other acquires its own specific features. Nature in the North has not been studied nearly as much as in the more southerly regions. Economists often bewail the fact that the creation of an infrastructure (roads, sources of electric power, settlements, etc.) occurs at the same time as the rapid, most capital-intensive period of the development of natural resources, and this complicates their rational development.

Preparation for the development of a new region entails the study of its natural conditions and their technical and economic evaluation, the scientific elaboration of exploitation methods, taking into consideration the consequences of man's interference in the existing balance of nature, the determination of ways of controlling the resulting processes and using advanced technology for this(16). Such a complex, but essential program of work should be carried out before or at the start of the compilation of the technical and economic evaluation and the technical and economic documentation for all far-northern industrial centres and main transport lines.

From the foregoing we can draw the following conclusions.

1. The components of the natural world of the North are easily disturbed and their capacity for self-recovery is far less than in any other zone. In consequence of this the natural and territorial complexes (topography, biocoenoses, ecosystems) are also unstable and highly vulnerable. After being disturbed they begin to manifest unique chain reactions of change, which lead to degradation of the natural systems of the North. If such changes are allowed to go on unchecked, they will lead to a deterioration of the environment: the formation of tundralike swampland, disfigured by thermokarst ravines and holes, etc., and the disappearance of animals. If these changes are controlled, the damage can be reduced considerably.

2. Taking this into consideration, it is clear that the complex of natural conservation measures in the North must be rigid and well thought out, because the destruction of natural systems in the North carries with it the danger that part of the local population of the North could be deprived of their traditional occupations (reindeer husbandry, hunting, and fishing).

3. The soil and subsoil, the freezing and thawing of which is extremely dangerous at the construction sites of costly industrial buildings and transport installations, should be studied with particular care.

4. The application of strict natural conservation measures coupled with the focal nature of industrial and transport development will make it possible to preserve the vast northern lands between industrial islands and exploit the renewable, particularly biological, resources properly, by developing reindeer husbandry, fishing, hunting, and strictly controlled tourism, including licensed hunting and fishing.

5. Plans for development, particularly industrial development, in the North should rest on the theoretical concepts of ecology, which, for this region, have not yet been fully elaborated[8,9,17]. The main ecological problems in the Subarctic which require further elaboration are: a) the principles governing the protection of ecosystems (natural complexes, terrain); b) the patterns and ways of changing the soil and subsoil (usually permafrost) when it is unavoidably disturbed in the process of industrial development; c) the elaboration of agrotechnical procedures for the purpose of extending arboreal growth further north in the relatively treeless tundra belt and the creation of green belts in the industrial centres of the Subarctic; d) the principles governing the utilization of the natural resources between industrial centres; e) research for the purpose of establishing recreational zones in the Subarctic.

The inadequate amount of research devoted to ecological problems and the existence of a certain gap between the rate of northern development and our knowledge of the North, plus the difficulty of rational development in the absence of a unitary scientific concept of the North, are indications that we should support the idea of establishing a Subarctic Institute, put forward in a number of reports[9,16,18,21].

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THE DYNAMICS OF NATURE IN NORTHERN REGIONS AND MEASURES TO CONSERVE AND IMPROVE THE ENVIRONMENT

(taking the West Siberian North as an example)

The development of our country's northern regions has been going on for many years. In recent times it has acquired the character of a large-scale integrated project.

The rapidly developing economic exploitation of the natural resources of the North calls for a differentiated approach to the various parts of its vast territory and constant preoccupation with the problem of environmental conservation and improvement. This applies especially to a rapidly developing region like the West Siberian North, and in particular to the very swampy part of the taiga regions, the Near-West Siberian North, where vigorous development of the oil industry is taking place together with the associated construction of a transport system, large-scale industrial installations, towns, and work camps.

The North, as we know, is being developed selectively, not *in toto*. In the selection of prime regions it is essential to consider the differences between individual regions, not only in terms of their natural resources, but from the point of view of the conditions of developing them and the need for environmental conservation and improvement. In this connection and in feasibility studies of the possible future development of northern resources an important place should be assigned to a true estimate of the oil-and gas-bearing areas, and industrial and civil construction sites in the light of geographical considerations. As a rule, it is not simply the characteristics of individual components of nature, such as relief, soil, surface moisture, bogs, forests, river valleys, lake basins,

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Problemy Severa, (18): 64-79, 1973.

etc., that assume special importance, but an analysis of the interaction of all or some of the components of nature in the given region.

Long-term forecasting of the integrated utilization of natural resources should not rely solely on an analysis of the present natural conditions, but should take account of the objective laws governing their development and the purposeful changes caused by the introduction of economic activities.

Analysis of the dynamics of nature. Our knowledge of the geography of the country's northern regions, including West Siberia, is extremely patchy. Whereas the riparian, more settled and comparatively accessible places have been described in many works and from different points of view, the boggy inaccessible interfluvial areas have, until very recently, been given comparatively little attention. The material on long-term observations available at meteorological and hydrological stations will not suffice to fill in the gaps in our knowledge.

An analysis of the available published stock, field, and, mainly, air photo-survey material, using a new method suggested by us, has made it possible to ascertain the characteristics of the evolution of nature in the West Siberian North[12,13,15]. A series of maps was compiled, showing the interaction (course of evolution) of geographical units and phenomena in the West Siberian North [7,8,10,15,16]. With these it is possible to estimate in sufficient detail the characteristics of the course of evolution of nature in any northern region for the purpose of substantiating hypotheses of future resource allocation and development.

As an example we shall give a brief run-down of analysis of the dynamics of nature in two specific places in the West Siberian North. These are shown on fragments of aerial photographs (Figures 1 and 2). First we shall specify certain conditions of their selection.

1. The photographs show sharply differing natural formations under approximately identical geographical conditions, with diametrically opposed courses of evolution of a component of nature. The first shows a comparatively raised and fairly broken terrain occupied by forests of the middle taiga variety, while the

second portrays the relatively flat surface of an interfluve with approximately the same true altitude, occupied by a vast oligotrophic boggy massif.

2. In terms of the characteristics of the course of evolution, the first photograph shows terrain subject to intensive swamping, and the second a well-drained plain where the bog is being replaced by forest vegetation.

3. The terrain selected must be typical of the West Siberian North.

The first photograph depicts a sector of a comparatively elevated plain (A) and part of a river valley (B). The surface of the plain is being subjected to general oversaturation. The existing network of ravines (a_1) and valleys (a_2) does not ensure normal surface-water outflow. There are no traces of fresh erosion dissection; everywhere there are turf-covered slopes. Even small flat areas of the plain are being swamped (a_3). Bogs have claimed not only terrace surfaces (a_4), but sections of river valleys (a_5). The river valley shows clear evidence of ageing; the bed has an extremely complex pattern of meanders (b_1). Numerous intricate oxbows (b_2) are scattered about the flood plain. Almost all of the flood plain (b_3) and the first flood plain terrace (b_4) is being actively transformed into swamp. In the river valley there are clearly expressed traces of lateral erosion (b_5) and alluvial deposits (b_6) everywhere. Tree and shrub vegetation is preserved alongside the river bed (b_7) and on the higher berms running adjacent to the bank (b_8).

In terms of neotectonic characteristics the sector under discussion belongs to the Khanty-Mansi Depression[22,23]; in terms of the course of evolution it belongs to the Nadym Lowland and the eastern Belogor'e with their pronounced accumulation processes.

The terrain is exceptionally difficult for economic exploitation. Simply to conserve nature here means to await the generalized development of bogs, which are displacing tracts of middle taiga forest. To improve the natural conditions of this area would require large-scale land reclamation projects, which would inhibit the swamping processes (even though only locally). Under present

conditions tree vegetation that has been cut down is hardly ever renewed, while large forest areas are being swamped. When the terrain is developed, either in the near or distant future, land reclamation will have to be envisaged (within and outside the limits of a specific sector), which would facilitate a change in the course of the development of the bog formation process.

The second photograph (Figure 2) shows an almost unbroken sector of an interfluve (A) and a thickly wooded river valley (B), jutting deeply into a bog.

Here we have a photographic record of the initial stage of a radical transformation of nature in an interfluve. The systems of secondary lakes (a_1) and the oversaturated pools* (a_2) are associated with depressions inherited from an old drainage system (a_3) buried under the peat bogs. These mark the main directions of a future erosion incision (a_4), which are indicated by broken lines. The most waterlogged parts of the bog and the chains of pools and lakes become favourable places for the growth of arboreal vegetation once the excess water has been removed. The largest areas along the main water course (b_1) are already occupied by forest. On all sides of the main water course and deep into the interfluve the invasion of "ryama"** vegetation (b_2) is increasing - a vanguard of the taiga. It also extends far from the present-day river beds in the centre of the swampy interfluve (b_3). This is due to the active outflow of water from the peat bogs into depressions. The directions in which the bog water drains are indicated by arrows in the illustration. Given the present-day course of evolution, all of the interfluvial area in question will eventually be drained and the bogs replaced by forests.

In terms of tectonic conditions this region belongs to the positive uplifts of the Dem'yan group[(23)]; in terms of evolutionary characteristics it belongs to the Dem'yan-Vasyugan Plain with well-expressed denudation processes in the interfluves.

* Mochzhina - Translated as "pool", is a wet, soft, hummockless area of a swamp. (Transl. Ed.)

**Ryama - in Western Siberia, a sphagnum peat bog (muskeg) with low stands of *Pinus sylvestris* and *Pinus sibirica*. (Transl. Ed.)

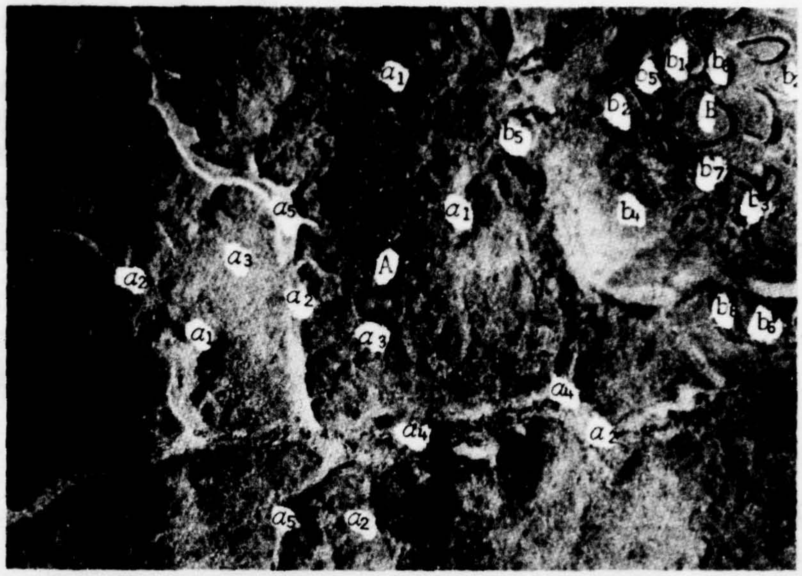

Fig. 1

Fragment of aerial photograph showing a sector of terrain with progressively (intensively) swamped forests and the flood plain of a river with pronounced accumulation processes. An explanation is given in the text

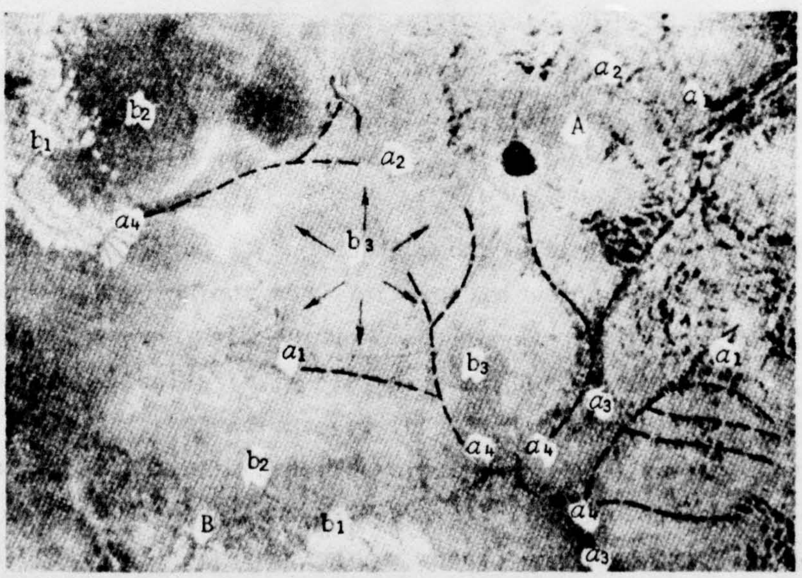

Fig. 2

Fragment of aerial photograph showing a sector of terrain with progressively (well) drained bog. An explanation is given in the text

Under present conditions economic exploitation of the locality in question, especially the very swampy areas, would entail considerable difficulties. However, if comparatively minor land reclamation measures were to be undertaken, the area could be radically transformed and improved within a short period of time. Then the dried-up plain could be utilized for intensive industrial, civil, transport, and agricultural construction. The economic assessment should include comparative calculations for development under different conditions. It is believed that expenditures on reclamation work would be repaid a hundredfold as a result of the reduced cost of all the development processes in the improved environment.

Differentiation of northern regions by dynamic criteria. From the available material we can compile not only a "complete" morphogenetic description of the natural formations recorded on the aerial photographs but also demonstrate the dynamics of the interrelationships of the components, phenomena, and formations of nature[14]. Let us examine, against this background, one of the country's northern regions - the Khanty-Mansi National Okrug.

In the West Siberian North the territory of the Khanty-Mansi National Okrug* overlaps the boundary of the wooded bog zone while individual parts of it belong to the northern (A), middle (B) and southern (C) wooded bog subzones (Figure 3).

The northern plain wooded bog subzone (Figure 3, A) is characterized by very complex forms of mezo- and microrelief when subjected to minor disturbance: accumulative-glacial ridges and mounds, thermokarst pits, erosion valleys, etc. This is reflected in the nature of the structure of first and second order river valleys and in the distribution of arboreal vegetation and peat bogs. Permafrost causes solifluction processes. These are associated with the exceptional smoothness and flatness of the slopes of river valleys and shores of lakes. In addition to this, thermokarst pits occur in places in the subzone. The largest peat bog masses or deep lakes are frequently associated with the sites of old thermokarst subsidences.

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* The territory of the Okrug encompassing the eastern slopes of the Urals is not dealt with in this article owing to lack of data.

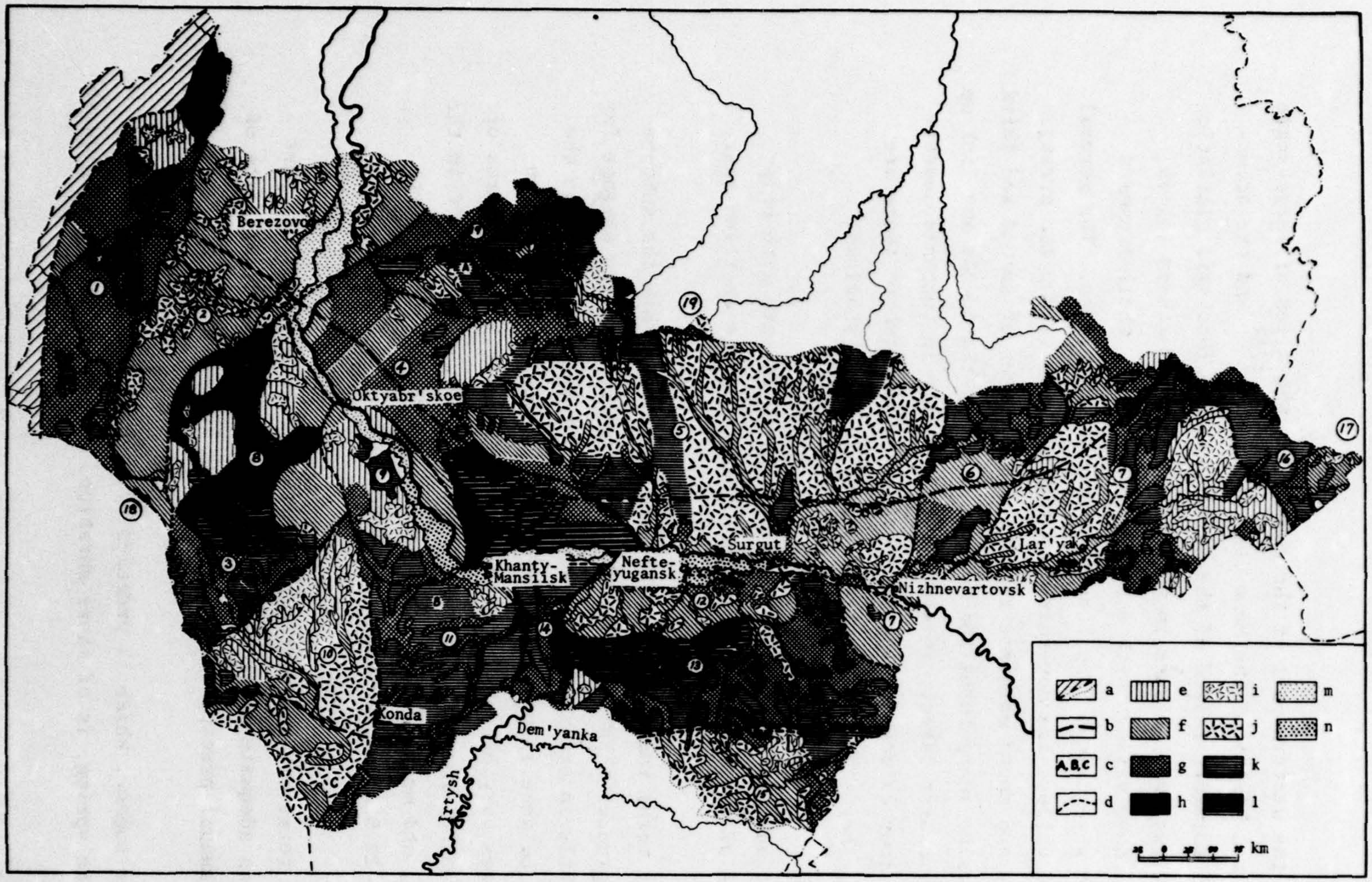

Fig. 3

Key map of the course of evolution (dynamics) of nature in the Khanty-Mansi National Okrug.

a - boundaries of the Khanty-Mansi National Okrug: oblast boundaries and territory for which there are no data on the course of evolution of nature, intra-oblast boundary of the Okrug; b - boundary of natural subzones; c - subzone indices; A - northern wooded bog; B - middle wooded bog, and C - southern wooded bog; d - boundaries and numbers of large areas of the wooded bog zone with spontaneous characteristics of the course of evolution (dynamics) of nature; e - progressively (well) drained forest areas; f - satisfactorily drained forest areas; g - poorly drained forest areas; h - forest areas undergoing progressive (intensive) swamping; i - progressively (well) drained bog areas; j - satisfactorily drained bog areas; k - poorly drained bog areas; l - bog areas undergoing progressive (intensive) oversaturation; m - flood plains of rivers with intensive accumulation processes; n - flood plains of rivers with weak accumulation processes

In the western part of the subzone at the sites of large-scale tectonic uplifts and basins of the Meso-Cenozoic period[23] and the occurrence of terminal morainic relief of the Zyryanskii and Tazovskii glaciation epochs[5,6], numerous small rivers in the basins of the Northern Sos'va, Lyamin, Pim, etc. have valleys with a complex structure: their expanded sectors alternate with unique "gaps" between mounds and ridges. The general directions of the valleys are determined by tectonic faults and the arrangement of the ridge and mound morainic relief. The courses of second and third order rivers describe sharp turns and complex bends at the mounds and link up morainic and thermokarst lakes. In some places (mostly in tectonic depressions) the river courses meander a great deal, in others (where there are gaps in moraines) they straighten out and abound in stony shallows.

The subzone is characterized by a harsh climate with only slight variations of the main meteorological indices in the west and east.

The total radiation for the summer period within the subzone is 8 - 10 times greater than it is for the winter period and the average for the year is slightly in excess of 70 kcal/cm^2. For the whole subzone the annual radiation balance is positive, from 5 to 10 kcal/cm^2. The mean annual temperatures vary between -4 and -9°C with mean July temperatures of 13 - 14°C in the northern part of the subzone (Salekhard), up to 16°C in the south (Berezovo), and mean January temperatures of -24.5°C in the north (Salekhard) and -22.5°C in the south (Berezovo).

In terms of atmospheric precipitation the northwestern part of the subzone has adequate moisture (300 - 400 mm). In the other parts of the subzone the annual precipitation levels reach 500 - 600 mm.

The summer, which is preceded by a sharp increase in the air temperature in the spring, is of short duration. The frost-free period lasts

only 48 - 72 days. The transition to fall is very sudden. The short fall season is characterized by frequent ground frosts, fog, and snow. From the end of October the temperature remains below freezing until the following spring.

Winter is the longest season of the year. Minimum air temperatures reach -54 and -56°C. The snow cover lasts from the beginning of October and disappears at the beginning of June, having lasted for 200 - 230 days.

The subzone's islands of arboreal vegetation are underlain by insufficiently drained sandy and loamy soil and are represented by northern taiga larch-spruce-Siberian pine forests with birch groves. The gleying processes in the podzolic boggy soils supporting these forests play an important role. Vast areas of pine and reindeer lichen on gley-podzolic and sandy and sandy loam soils are confined to hilly, broken, drained terrain. In addition, larch-spruce-Siberian pine forests are widely developed on sandy-loamy gley-podzolic soils with sphagnum bogs. Vast expanses in which accumulation processes predominate contribute to the bog vegetation.

In the north of the Khanty-Mansi National Okrug there is a region of large-hummock peat bogs. These are distinguished by the presence of large, high peat hummocks, formed as a result of frost heaving when water freezes in a peat mass, underneath peat, or in the layers of clay and clayey loam underneath a peat mass. Their height (1.5 - 2 to 11 m) and prominent crests distinguish them from the low, flat-topped hummocks [17,18,9]. The depth of the peat layer reaches 2.5 m or more. The hummocks vary in area and profile. Large hummocks form a complex, sometimes with pools, sometimes with drier depressions in which the sphagnum mat is overgrown with shrubs, and at other times with small lakes. The large hummocks in these complexes are usually dispersed singly at considerable distances from

one another and often form part of bog complexes of complicated structure, and by no means everywhere do they determine the landscape zones, being confined solely to heavily saturated depressions[1].

Large-hummock peat bogs occur locally, within the province, depending on the development of the meso- and microforms of relief. Thus, for example, in swales* and on the Lyapin Lowland (Figure 3, No. 1), there are few large-hummock peat bogs. As a rule the hummocks are scattered among sphagnum bogs. Their development depends on an adequate seepage of bog water to the frozen nuclei of the large mounds. The prominent friable crests of these hummocks, in the majority of cases, are bare of vegetation, while the sides are covered with *Eriophorum viginatum*, cloudberries, wild rosemary, and lichen. One of their distinguishing characteristics is the ease with which they disintegrate. In the winter the tops of the hummocks are blown away very rapidly by strong winds, while the slopes disintegrate during thaws. The hummocks are, as it were, forced open by frost cracks.

The remainder of the Okrug (within the plain) is characterized by the widespread occurrence of domed (oligotrophic) ridge and bog, pool bogs. They frequently occupy water divides of both the first and second order.

The flat interfluves are occupied by a colossal tract of bog, or more precisely, a system of confluent bogs, many hundreds of kilometers in length. The peat bogs here have domed surfaces, the centres of which are as much as 5 - 7 m higher than the edges. In the process of the unhindered breadthwise growth of oligotrophic bogs a special form of relief has evolved - a well developed, more or less horizontal, plateau with gently sloping long marginal slopes comprising half the length of the cross section of the large peat bogs.

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* Literally: intercrest depressions. (Transl.)

Large conglomerations of secondary lakes (their basins are formed in the peat mass) and bog pools are confined to the central parts of peat bogs where, because of their flatness and remoteness from the marginal areas, the atmospheric water cannot drain away and conditions conducive to excessive moisture are created[8]. In depressions on the central peat plateau where a relatively large amount of water accumulates, the lakes, frequently separated only by narrow peat ridges 0.5 - 0.8 m high, form groups, known as lake complexes. Most of the forms (elements of bog microrelief) are of nonerosional and unique accumulative origin - the result of the nonuniform growth rate of the peat bed in different sectors[21].

The domed sectors of a sphagnum peat bog, which facilitate the runoff of some of the bog water, are overgrown with depressed pine trees and shrubs on a continuous sphagnum cover (a pine-shrub-sphagnum complex). Trees growing in over-saturated soil and accretions of moss cover put out secondary roots in the topmost soil horizon. Sometimes these roots are arranged in 2 - 3 layers[3], which, as they develop, serve as indicators of the intensity of the soil swamping and the increment of the moss cover.

Bogs which are characterized by a well-developed lacustrine, ridge-bog pool, pine-shrubs-sphagnum complex and which are distinguished by clear interpretive signs, represent the final stage in the development of an oligotrophic peat bog. Further moisture must result in either an expansion of its area, or the active shedding of surplus water. In the first case, there is, as a rule, a rapid increase in the size of the peat bed, and in the second case what frequently happens is that the large tract of bog breaks up into smaller tracts, which undergo draining for a lengthy period.

On small bogs which have limited opportunities to expand in breadth (for example, those located on second order water divides) the area of the central plateau is reduced at the expense of the slopes. As a consequence of this, and also on account of the nearness of the marginal areas to the central plateau, such bogs are better drained and pine-shrub and ridge-bog pool complexes predominate on their surfaces. Small bogs lack a central plateau and the drained slopes are occupied by a pine-shrub-sphagnum complex. Small young bogs, formed as a result

of a recent merging of separate bog formation foci, have virtually flat surfaces. Here a pine-cotton grass-sphagnum complex predominates; there are pools, but lakes have not developed[2].

Sometimes it is asserted that the microrelief patterns on oligotrophic bogs have little to do with environmental conditions (except climatic conditions), but are determined primarily by the inherent laws of peat bog formation[21]. Obviously climatic conditions should not be considered the only exception. The slightest changes in the bog formation characteristics give rise to striking qualitative and quantitative "disturbances" in the formation and distribution of the biomass. And this is especially characteristic of the active layer, i.e., the layer in which the processes of matter and energy exchange with the environment are most strongly developed.

Larch, spruce, and Siberian pine stands with admixtures of birch and pine amid vast expanses of swampy land form the northern taiga forests, which extend in a broad belt (from 250 km in the west to 550 km in the east). Larch and dark coniferous-birch-larch forests with a moss-lichen and shrub cover occur most widely in riparian regions. Here gleyed-podzolic soils have developed; these are replaced in excessively water-logged places by podzolic-bog (down to 100 - 150 cm) and peat-bog soils.

Separation of the dark coniferous and larch northern taiga forests takes place, depending on the moisture characteristics of the soil and subsoil. Larch forests occupy the better drained areas. On sand, larch forests with admixtures of pine create transitional associations to pine forests. Pine-larch and larch-pine forests, combined with pure larch forests are most characteristic of the northern taiga. Here the arboreal layer is stunted and sparse, with a density of 0.4 - 0.5, and quality of V, rarely higher. Pine forests in this subzone have a density of 0.5 - 0.7 and a quality of V - IV. Ninety to 100-year-old pines barely reach heights of 8 - 11 m, with chest-height diameters of 16 - 20 cm and crown densities of 0.2 - 0.4. In the better pine forests the trees reach a height of 22 - 24 m at ages between 160 and 200 years and timber reserve of 280 - 300 m^3 per hectare[4].

Stunted sphagnum pine forests are widely distributed in the northern taiga. These form unique transitions from bogs to pine and pine-larch forests. The plants which predominate on the podzolic-bog and peat-bog soils among the depressed pine forests are sphagnum mosses, isolated beds of green moss and lichen, as well as dwarf semishrubs and, on the bog fringes, a dense undergrowth of yernik*.

Dark coniferous mixed forests of spruce and Siberian pine (with maximum densities of 0.6), sometimes with admixtures of birch and larch, grow on adequately and well drained gleyed-podzolic soils on the sides of river valleys and elevated interfluves. Along rivers they form narrow belts (Figure 2), which stand out sharply against the background of dominant pine and larch depressed forests.

Natural conditions throughout the entire wooded bog subzone are not very favourable for the development of agriculture, especially crop farming.

The middle wooded-bog subzone(Figure 3, B), which makes up a large part of the Khanty-Mansi National Okrug, is characterized by a continental climate with a long and comparatively harsh winter and maximum precipitation during the warmer part of the year. The mean annual air temperatures within the subzone vary from -0.5 to -4.0°C. The mean January temperatures in the east and west of the subzone differ only from -20 to -23°C. The mean July temperatures do not exceed +16 and 17.7°C. The total annual precipitation varies between 500 and 580 mm.

The subzone is distinguished by a combination of widely developed dome (oligotrophic) ridge bogs with pools associated with almost all of the flat or slightly sloping parts of the plain and tracts of taiga on drained slopes.

Vast expanses (up to 60 - 70% of the total area) are occupied by bogs. Their morphological characteristics differ in relation to the features of the developed meso- and microforms of relief.

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* "yernik" - dwarf shrub formation with *Betula nana* occurring in polar and alpine regions. (Transl.)

Swale peat bogs[7,9], which belong to the province of oligotrophic ridge bogs with pools, and domed peat bogs, occur widely in the Ob-Irtysh interfluve, the basin of the Konda River and north of the latitudinal segment of the Ob Valley. Peat bogs in closed elongated swales have maximum thicknesses of 5.5 - 9 m. The bottoms of the depressions are filled with clayey deposits (mainly of lacustrine-glacial origin), silt, or layers of compacted sand. These soils create impervious horizons and facilitate bog formation. Forest islands occupy elevations amid otherwise continuous bog terrain (the basins of the Konda, Bol'shoi Salym and other rivers).

Swale peat bogs are widely distributed in the Surgut forest area (see Figure 3, contour 5). Here numerous lakes and bogs form a unique lake-bog complex. Individual forest islets and belts are scattered here and there among the bogs and along river courses. Slightly more than 2 - 3% of the area of the interfluves in the Surgut forest area is occupied by forest vegetation.

The largest lakes, such as Iki-Ing-Lor, Vyrtl'-Sam-Lor, Onktyn-Sort-Lor, are 4 - 6 km in diameter and have rounded shapes. Indications of two or three stages in the shrinkage of their water area are recorded in the shore belts of these lakes. There are more of these "shrinking" lakes in places where progressive denudation processes are taking place (see Figure 3). Chains of miniature lakes mark the location of buried swales. In addition to secondary lakelets, chains of heavily oversaturated bog pools are associated with the convex surfaces of peat bogs, the maximum thickness of which (2 - 3 m) occurs in the central parts of the swales.

Sphagnum peat moss with a low ash content predominates everywhere. The bog surfaces are formed of partly decomposed sphagnum mosses, scheuchzeria-sphagnum turf, and pine-shrub-sphagnum associations. It is not always possible to trace the contours of peat bogs among the intricate present-day ridge-lake-bog complex of the Surugut forest area[9,11].

Areas of peat bogs associated with swales are readily identifiable in the Konda River Basin. In many places individual swales are covered with peat bogs combined into a single bog tract. Peat bogs with domed areas are being

actively eroded by a multitude of miniature secondary lakes. Here more than 60% of the area consists of oligotrophic domed peat bogs the thickness of which has been determined as 4 - 5.5 m. Fragments of ancient swells and swales have been preserved on the interfluve of the Keum and Bol'shoi Salym, in the upper reaches of the Samsonovskaya River. Some depressions are occupied by a system of elongated lakes (Navyemskie, Tog-Ega, Dolgii Sor), others by enormous peat bogs (high moor peat predominating) up to 5.5 - 6 m in thickness. Observations in this region confirm that peat bogs in individual swales have long since outgrown their capacity and many of them have now merged into a single peat mass with an extremely complex surface and inner structure.

A large agglomeration of oligotrophic peat bogs is associated with unique wide flat-bottomed depressions - ancient drainage troughs[7]. Of the greatest interest in this connection are the ancient drainage troughs in the basins of the Northern Sos'va, Konda, Trom-Egan, Vakh, and Bol'shoi Yugan rivers. Peat bogs 3 - 5 m thick sometimes extend for several tens of kilometers inside these troughs. These are broken up by large lakes, rivers and tracts of taiga.

River valley peat bogs are convenient objects for both research and development. Almost all peat bogs of oxbow lake origin have passed through the lake stage. The dominant elements in these are partly decomposed remains of grasses, hydrophilous vegetation, often with large fragments of tree trunks. The topmost horizons of the peat bogs are covered with sphagnum mosses. The thickness of peat bogs in oxbow lake beds measured in the field varies within very wide limits; for example, in the basin of the Northern Sos'va River north of Aneeva settlement peat bog thicknesses in excess of 9 m were recorded.

From the geobotanical point of view there is no sharp transition between the northern and southern taiga regions.

The overall thickness of the podzolic soil profile is 120 - 150 cm with a thin (3 - 10 cm) humus horizon and well-expressed illuvial and eluvial horizons. The chemical and mechanical characteristics of podzolic soils indicate that they have a low level of productivity. Podzolic-boggy soils of the middle taiga regions are distinguished by their well-expressed humus and humus-illuvial

horizons. They develop in adequate moisture conditions beneath depressed tree stands with a well-developed moss cover.

Siberian larch forests are almost completely absent in the middle wooded bog zone, although larch is encountered universally in the composition of other stands. Spruce-fir-Siberian pine, and aspen-birch derived forests predominate in cleared and burned-over areas. The taiga is, for the most part a green-moss forest. The cover includes numerous species of plants not encountered in northern taiga regions (barberry, mayflower, paris).

In the Konda River Basin, on the Ob-Irtysh interfluve and the right bank of the Ob dark coniferous forest tracts occupy well drained and adequately drained areas, which, combined with the high moor bogs on water divides and river terraces, creates a complex distribution pattern of plant groupings. In the Ural regions spruce-fir-Siberian pine forests form an almost continuous cover on the broken surface of the glacial-accumulative plain. Here there is adequate drainage of atmospheric water. Middle taiga forests develop on drainage mounds, the slopes of ancient drainage troughs, and river valleys with podzolic soil.

All arboreal species of spruce-fir-Siberian pine stands develop normally. The trees grow very tall (20 - 25 m) with dense crowns; they bear fruit well and are of great value in the general timber resources of the West Siberian North. Here the timber reserve is as much as 400 - 500 m^3 per hectare. High densities (0.6 - 0.7) and quality groups III, IV and V are characteristic of the middle taiga dark coniferous forests.

Siberian pine and fir grow in slightly moist podzolic soils, fir developing better on loamy soils. Large tracts of green-moss Siberian pine forests are encountered. These are excellent hunting ranges and pine nut collection areas. Siberian pine forests provide top quality lumber.

The species composition of the green mosses and herbaceous vegetation of the middle taiga dark coniferous forests is almost indistinguishable from the northern taiga dark coniferous forests. The mosses in both are the

same: *Ptilium crista costrensis*, *Pleurozium schreberi*, *Hylocomium poliferum*

In wetter and less well drained areas spruce usually predominates in the stand of green-moss dark coniferous forests, though Siberian pine is also a very characteristic variety. The proportion of birch and pine depends on the density of the stand and the extent to which it has been affected by logging and fires[20].

Comparatively large areas of the middle wooded bog subzone are occupied by stands in which the common pine predominates: white-moss, green-moss, mountain cranberry, and billberry pine forests, as well as polytrichum and sphagnum (ryama) pine forests. By comparison with the northern wooded bog regions, the role of pine forests is somewhat limited. They occupy riparian ridges*, bars, and vast expanses of high moor bog, on which "ryama" depressed pine forests have developed. Mature pines of the II and III quality groups grow to a height of 25 - 28 m and develop trunk diameters of up to 55 cm[4]. "Ryama" pine forests are extremely depressed: 100 - 150-year-old trees barely reach heights of 8 - 10 m.

Two comparatively small areas of the Khanty-Mansi National Okrug on the Ob-Irtysh interfluve and in the Konda River Basin belong to the southern wooded bog subzone (Figure 3, C). They are associated with flat, poorly drained and lightly dissected water-accumulative plains. In some sectors more than 40% of the area is occupied by ridge-bogs with pools.

Domed bogs occupying water divides extend for considerable distances. In terms of species composition and the evolution of their peat mass they resemble the bogs of the middle wooded bog subzone.

The climate of the subzone is characterized by a continental regime of temperatures, precipitation and other elements. The mean annual temperatures vary from 0.1°C in the west to -0.5°C in the east of the Okrug. The mean January air temperatures are -18 and -20°C; the mean July temperatures are approximately +17°C. The total annual precipitation is 450 - 550 mm.

* "uval" - a low smooth elongated elevation with gentle slopes without a clearly expressed foot. (Transl.)

The riparian regions of plains and areas undergoing neotectonic uplifts are surfaces which are being actively drained. They are overgrown with forests, which to a large extent have been modified by man's economic activities.

Draining regions, where deciduous species form a significant proportion of the stand, are distinguished by intensified development of soddy-podzolic soils. In addition, podzolic soils (on sand), podzolic-bog soils and humus-peat-bog and peat-bog soils are clearly expressed here.

Soddy-podzolic soils of the southern wooded bog subzone show signs of gleization throughout the entire profile and they often have a second humus horizon. This is sometimes confined to the A_2 horizon or the top of the illuvial horizon. Despite its dark colour, this horizon is not always characterized by a high humus content compared with the horizon underneath it.

The soddy-podzolic soils of the western riparian and the eastern regions are the most valuable. They are rich in humus (up to and sometimes more than 5 - 7%). In the Konda and Dem'yanka regions the soddy-podzolic soils are somewhat poorer in humus in the surface horizon (3 - 5%), and are distinguished by above-average acidity and a lower saturation level.

Podzolic, podzolic-boggy, and peat-bog soils in the southern taiga regions of the Okrug for the most part have the same properties and peculiarities as similar soils in the northern regions of the Okrug.

The predominance of fir and the occurrence of islands of linden are characteristic of the southern taiga.

Compared with the middle taiga, the areas of pine forests are noticeably smaller in the southern taiga, although their role is not reduced. In many places in the southern part of the Okrug bogs are considerably larger in area than the forests.

The map of the dynamics of nature in the Khanty-Mansi National Okrug (Figure 3) shows areas which are similar or different, not with respect to some

natural indicant (climate, relief, vegetation, etc.) or a combination of morphological indicants, but in terms of characteristics of the course of evolution (dynamics) of their natural conditions. Taking these into consideration, 19 large sectors with spontaneous characteristics of the dynamics of nature have been identified within the boundaries of the Khanty-Mansi National Okrug.

The map shows well, satisfactorily, and poorly-drained forest areas, forest areas that are being swamped; well, satisfactorily, and poorly-drained bog areas; bogs which are becoming oversaturated; the flood plains of rivers with intensive and weak accumulation processes.

The words "well" and "intensively" are used in connection with several features of the interrelationships of components of nature: where draining or swamping affects more than 70% of the area of a sector; where draining or swamping that has only just appeared may in future affect more than 70% of the area; radical transformations of nature that are taking place at an accelerated rate.

The word "satisfactorily" is applied where draining or swamping of tracts of forest and bog affects 50% of their total area. The word "poorly" indicates that the drained surfaces of a specified sector of the plain comprise less than 50% of its area, while accumulation processes predominate over denudation processes.

Such relative quantitative values are justified when comparing large areas and compiling small-scale maps.

An analysis of the dynamics of nature permits us to make a specific judgment about the prospects of the economic development of a particular unit of uniform terrain.

It is not the purpose of this work to compile descriptions and examine the characteristics of economic development for all the uniform terrain units in the Okrug. At the same time this does seem to be an opportune point at which to state the general conclusion that the units most suitable for priority

economic development include: well-drained forests, satisfactorily-drained forests, intensively-drained bogs, satisfactorily-drained bogs, and the flood plains of rivers with weak accumulation processes. Such units are scattered all over the territory of the Khanty-Mansi National Okrug and are associated primarily with large sectors with autonomous natural dynamic features[2,5,7,9,10,12,15,17,18] (Figure 3).

The main characteristics of the course of evolution in such areas can be summarized as follows: they are being freed of stagnant water, the areas of ground-water saturation are diminishing, erosion base levels are falling, and the surface and ground-water runoff capacity is increasing. Here sectors of the plain composed of loose deposits are subject to erosion dissection. Numerous streams and rivers cut through the peat and loose bodies of mineral soil and drain them with comparative ease and rapidity. Bogs give way tc forests. Podzolic well-moistened soil is formed, rich in organic matter[11,13,15]. These and other indications of the course of evolution can, it seems, be regarded as favourable for economic development. Here many forms of economic construction, including the conservation and improvement of the natural environment, require smaller capital investments.

Completely different, frequently opposite, qualities are possessed by: poorly-drained forests and bogs, forests that are being subjected to intensive swamping, bogs that are being oversaturated, and flood plains of rivers with active accumulation processes. These occupy extensive areas in sectors 1, 3, 4, 6, 8, 11, 13, 14, 16 and 19 of the Okrug (Figure 3). Similar uniform units are encountered in other large sectors as well, but in terms of area and intensity of the transformation of natural component interrelationships they are not decisive.

These units are characterized by accumulations of stagnant water, increasing areas and volumes of ground saturation, higher erosion base levels, and reduced surface and ground-water runoff. Here intensive swamping is taking place, which makes the land unsuitable for economic development. On numerous counts such land belongs to the category "areas with difficult and very difficult conditions". Its economic exploitation would entail large expenditures of money and effort.

In elaborating a working hypothesis for the long-term development of the resources of the Khanty-Mansi National Okrug, we should, all other geological and economic indications being equal, give priority to the development of territories with the most favourable natural environment.

The subdivision of the West Siberian North according to natural features. Forests, bogs, broad flood plains, etc., which are characterized in each specific case by qualitative and quantitative indicators of the course of evolutionary dynamics, form dynamically uniform units. For example, such a unit may consist of satisfactorily-drained forests,bogs, and flood plains, as well as lake basins with weak accumulation processes and satisfactorily-drained agricultural land.

Each type of unit in a given natural subzone possesses special features from the point of view of economic exploitation, therefore,a detailed study of the course of evolution of a unit, as the smallest taxonomic unit of regional subdivision, has great practical significance. By assembling as much information as possible about the course of evolution of a unit, we are enabled not only to forecast, but to undertake specific measures for the transformation of its nature for the purpose of economic exploitation and the conservation and improvement of the natural environment.

Dynamically homogeneous units are combined into dynamically heterogeneous regions. For each region, uniformity of the course of evolution is essential. Depending on the natural features of a particular territory, several types of regions can be distinguished: regions with active denudation processes, regions with satisfactory accumulation processes, and regions with active accumulation processes. Thus, the dynamically homogeneous units of the Verkhnedem'yanka Hills, the Kaimysovskie Uplifts, the Srednevasyugan Plain (Figure 4, A, B and C) are combined into regions with progressive and satisfactory denudation processes, while the units of the Chertalinskaya (E) and Koltogorskaya (D) lowlands are combined into regions with satisfactory and progressive bog-forming processes.

Regions of dynamically different significance are combined into large sectors with autonomous characteristics of the course of evolution (dynamics). The

boundaries of these sectors depend to a considerable extent on the main features of the course of evolution within the natural zones.

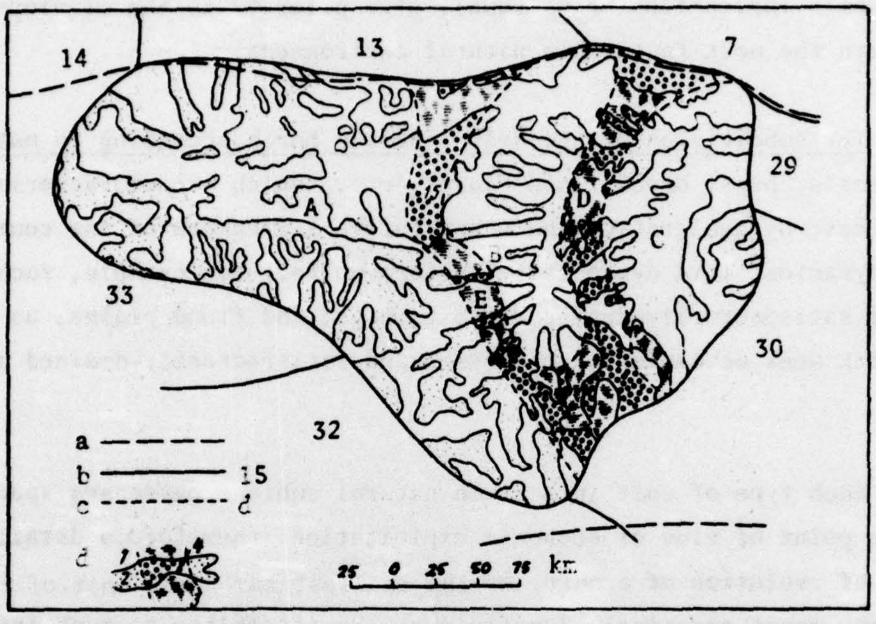

Fig. 4

Schematic chart of dynamically homogeneous unit in dynamically heterogeneous regions of the Dem'yan-Vasyugan Plain

a - subzone boundaries; b - boundary and number of large-scale sector of the wooded bog zone with autonomous characteristics of the course of evolution (dynamics); c - boundaries and designations of dynamically heterogeneous regions; d - boundaries of dynamically homogeneous units: 2 and 4 - forest units; 1 and 3 - bog units

The interaction of biological-climatic and geological-geomorphological components is clearly expressed. Accumulation or denudation processes of identical magnitude, area, and speed in various parts of natural zones differ not only in qualitative, but also in quantitative indices of material migration. Let us take an example. The indices of the denudation processes in the middle reaches of the Northern Sos'va, which have much in common with force, direction, and speed of similar processes in the upper reaches of the Bol'shoi Yugan, differ greatly with respect to the nature of the denudation processes, and the dynamics and composition of the material. Part of the Sos'va-Muzhi Uplands (Figure 5, No. 2) is characterized by the development of natural formations of the northern

and middle wooded bog subzones, while in the upper reaches of the Bol'shoi Yugan, on the Dem'yan-Vasyugan Plain (Fig. 5, No. 15), natural formations are developing under conditions of the southern wooded bog subzone.

Large sectors with autonomous characteristics of the course of evolution are combined into natural zones*, which express the close interrelationship and interlinking of the course of evolution of the components of nature. In the West Siberian North there are the tundra, wooded tundra, and wooded bog zones (Fig. 5).

Besides combining all the identified large-scale sectors with autonomous characteristics of the dynamics of nature into natural zones, they can be arbitrarily subdivided into two dynamic groups, of which the first includes sectors with active and satisfactory denudation indices (in Figure 5 such sectors of the Khanty-Mansi National Okrug are indicated by oblique crosshatching), and the second, sectors with diametrically opposite indices (in Figure 5 such sectors are indicated by horizontal crosshatching).

In the tundra and wooded tundra zones (Figure 5, I and II) the first group includes: The North Yamal Plain (1^1), the Sabyakhinskaya Plain (3^1), the Shuckinskie Hills (5^1), the Gyda Ridge (6^1), the Coastal Plain (8^1), the Dorofeevskaya Upland (9^1), the South Gyda Plain (10^1), the Turukhan Upland (18^1), the Nyda Plain (15^1), the Taz Plain (16^1), and the Pakulikha Plain (20^1). The Second group includes: the Neito Lowland (2^1), the South Yamal Lowland (4^1), the Tynge Lowland (7^1); the Taz Estuary Lowland (17^1), the Pur Lowland (12^1), the Nadym Lowland (14^1), the Makovskaya Lowland (19^1), and the Lyapin Lowland (21^1).

In the wooded bog zone (Figure 5, III) the first group includes: the Sos'va-Muzhi Upland (2), the Taz Upland (21), the Pakulikha Plain (23), the Endyr Plain (9), the Surgut Forest Area (5), the Pelym-Turi Plain (18), the Upper Konda Plain (3), the Tavda-Konda Upland (10), the Salym-Yugan Plain (12),

* Natural zones are subdivided into subzones, which do not have independent significance in the taxonomic system of units.

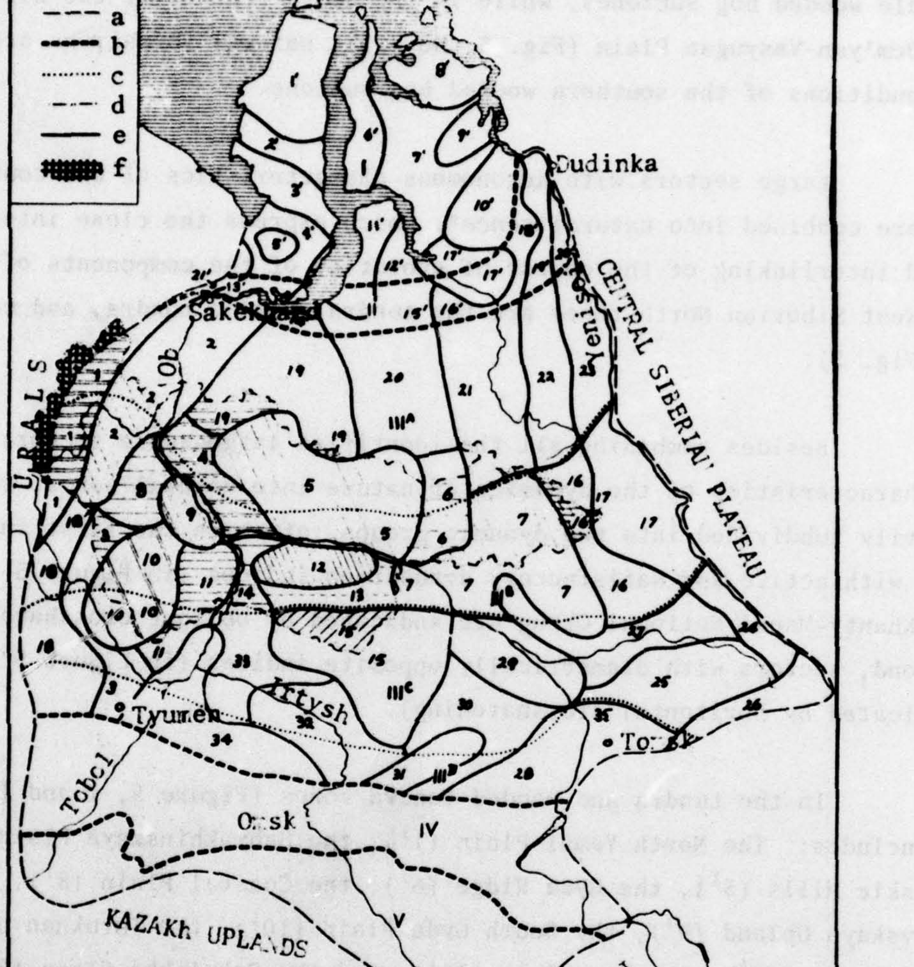

Fig. 5

Outline chart of subdivision of West Siberian North according to natural features

a - boundary of West Siberian Plain, b - boundaries of natural zones: I - tundra, II - wooded tundra, III - wooded bog, IV - wooded steppe; V - steppe; c - boundaries of natural subzones: III^A - northern wooded bog; III^B middle wooded bog, III^C - southern wooded bog, III^D - small-leaved swamp forests; d - boundary of Khanty-Mansi National Okrug; e - boundaries and numbers of large sectors with spontaneous characteristics of the course of evolution (dynamics); f - Okrug territory not studied in terms of the course of evolution (dynamics)

and middle wooded bog subzones, while in the upper reaches of the Bol'shoi Yugan, on the Dem'yan-Vasyugan Plain (Fig. 5, No. 15), natural formations are developing under conditions of the southern wooded bog subzone.

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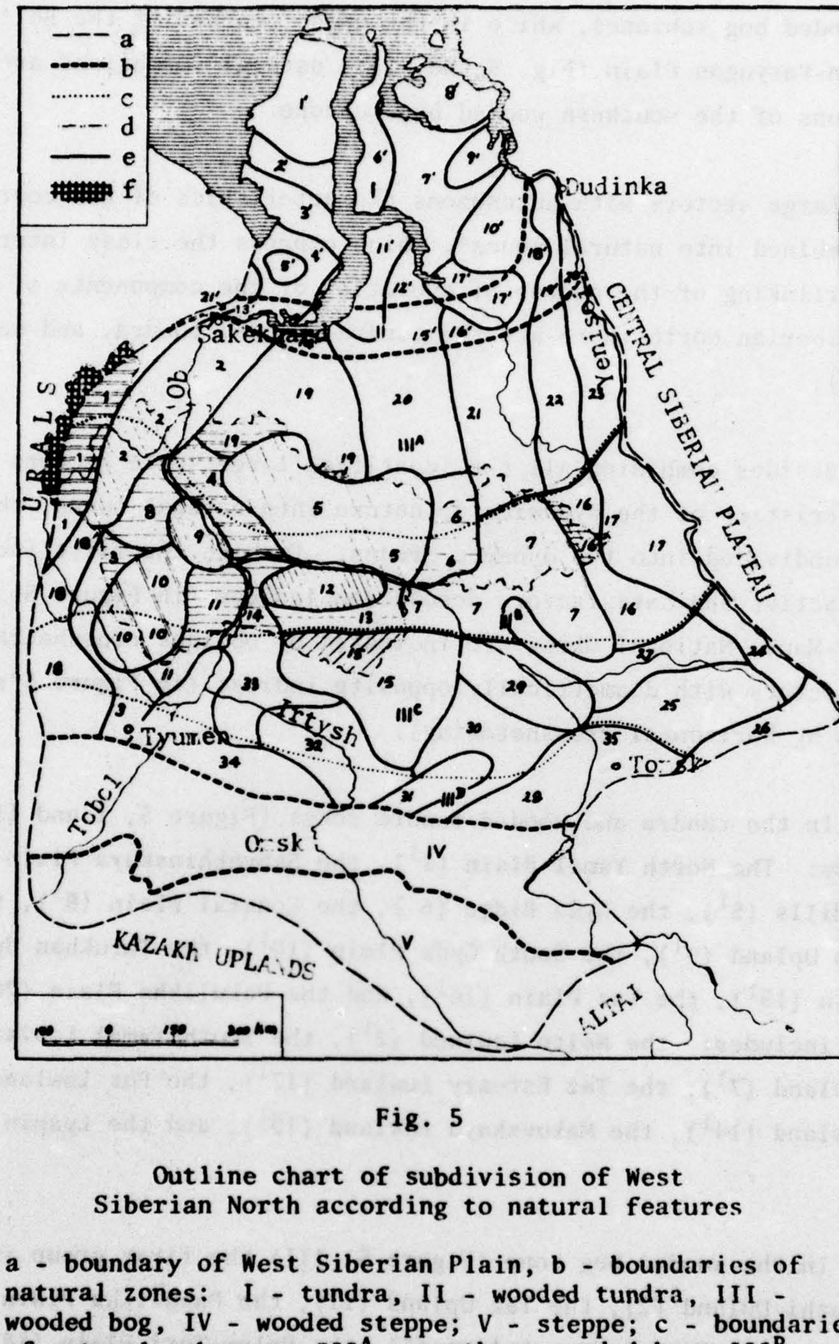

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the Dem'ya-Vasyugan Plain (15), the Middle Vakh Plain (7), the Parabel Plain (29), the Tebisskaya Upland (31), the Elogui-Sym Plain (17), the Yenisei Plain (24), the Ket'-Chulym Plain (27 and 35), the Tobol-Ishim Plain (34), and the Baraba-Pikhtovka Plain (28). The second group includes: the Lyapin Lowland (1), the Nadym Lowland (19), the Pur Lowland (20), the Khudosei Lowland (22), Belogor'e and the Nazym Lowland (4), the Vakh-Pur Lowland (6), the Khanty-Mansi Lowland (11), the Turtas-Keum Plain (14), the Yugan Lowland (13), the Tara Lowland (32), the Mezhovskaya Plain (30), the Vakh-Tym Plain (16 and 25), and the Priarginskaya Plain (26).

The taxonomic unit of regionalization, in our case, is the whole of the West Siberian Plain, i.e., a wilderness country. The northern area of the West Siberian Plain is distinguished by exceptionally clear indications of the dynamics of nature and it has comparatively well-defined boundaries with the adjacent wilderness countries - the Urals and the Central Siberian Plateau.

Qualitative and quantitative evaluations of the characteristics of the course of evolution for any natural regionalization units provide sound arguments on which to base the solution of northern development problems on the one hand, and the adoption of the necessary environmental conservation and amelioration measures on the other.

In our view the proposed approaches to the qualitative and quantitive evaluation of the dynamics of nature in development regions and the elaboration on this basis of concrete measures of environmental conservation and amelioration during the process of industrialization represent one of the most important analytical techniques in the economic assessment of the effectiveness of new northern developments.

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ZONAL FEATURES OF THE NORTHERN TAIGA ENVIRONMENT AND A SYSTEM OF CARRYING ON TRADITIONAL ECONOMIC ACTIVITIES

The geographical zonal pattern of nature as one of the basic physical and geographical laws was first defined by V.V. Dokuchaev as early as the end of the last century, and was further developed in the following decades in the writings of L.S. Berg, A.A. Grigor'ev, M.I. Budyko and others. Geographical zones are an established system at the base of which lie changes in the amount of solar energy, that is received by the earth's surface depending on the latitude. The actual location of the natural zones depends upon the annual radiation balance, the annual quantity of precipitation and the relationship between them, which is well expressed by the radiation index of dryness[1,2,3].

When the ratio between heat and moisture, which are expressed by the index of dryness, is close to 1, optimum conditions for the production of phyto- and zoomass are created. In other words, certain territories have the maximum productive biocenosis. In our latitudes, which receive annually from 0 to 50 kcal/cm^2, this optimum range is found within the limit of the natural zones covered with broadleaf forests and forest steppe. (The radiation index of dryness is 0.8 - 1). Further to the north, as the amount of heat received by the surface of the earth declines, a surplus of moisture occurs which results in a drop in the radiation index of dryness within the limits of the mixed forests and the southern taiga to 0.6 - 0.8, in the central and northern taiga to 0.4 - 0.6, in the tundra to 0.2 - 0.4, and in the arctic deserts to 0[4].

Problemy Severa, (18): 80-86, 1973.

These formulations by geographers are accepted by botanists, zoologists, bioceonologists, and other specialists who study the biological components of the geographical envelope of the earth and its biological resources. In spite of a number of factors which hinder the manifestation of latitudinal zonality, nevertheless it does determine the possible causes of the biological production specific for various territories. This applies both to the wild and the cultivated components of the biosphere - soils, plants and animals. Consequently, at the present time no one doubts the need for a zonal system of management in agriculture. This is the direction of numerous research projects in respect to basic agricultural regions.

The same need is obvious for the northern territories as well, both with respect to agriculture of the usual kind (land cultivation, animal breeding) and the traditional economic sectors, the activities of which are based on the utilization of wild biological resources. Wild plants and animals depend to an even greater extent on the surrounding environment, and consequently are subject to the laws of geographical zonality.

For a correct delineation of the zonal system of managing the economy it is not enough to consider the natural zones as a whole in their present day sizes. They are too big in terms of territory and too different in natural conditions. This is particularly true of the northern zone - the taiga and the tundra. It is essential to consider the division of the natural zones into subzones, and in some cases to subdivide them even further, especially if the latitudinal extension of the zone is very great.

Here we shall consider the special zonal features and the specific ways of managing traditional economy sectors within the taiga zone, which is the most extensive natural zone in our country.

All the zonal indices of the territory, which also includes its biological productivity, vary with the change of latitude. Yet the taiga zone, as it is understood today, has a very long latitudinal extension. It stretches in places over more than 1,600 km from north to south. This is much more than the extent of our other natural zones (tundra zone of up to 600 km, forest-tundra zone 250 km,

forest steppes up to 450 km, steppes up to 950 km, semideserts up to 670 km, the desert zone 990 km[8].

As a result of the great latitudinal extension of the taiga the basic zonal indices vary considerably within its limits, resulting in considerable changes in plants and animals which are very sensitive in their reaction to changes in the water and heat balance. For this reason the concept of the taiga as a single natural zone has been in doubt for a long time. There will probably be in the immediate future a final reassessment of the idea of the taiga being a single natural zone, since the three main subzones of which it is composed could quite successfully be considered as independent separate natural zones.

The subdivision of the taiga into a system of subzones has been successfully resolved by physical and botanical geographers. The most conservative in this respect are zoogeographers, zoologists, hunting economy experts and other specialists, who are engaged in research on the biological resources and the traditional economy of the taiga. The present systems of regionalization in the North with respect to the hunting economy and other traditional activities (especially in the taiga regions) as a rule do not take into consideration the natural differentiation of the territory. As a basis for subdividing the taiga for traditional economic activities one of the alternative economic regionalizations of the U.S.S.R. is usually adopted[5]. In the above-cited reference on the economics of traditional activities it is not denied that there is a necessity to consider, along with the economic aspect, the natural zonal characteristics of the territory as well. "The task of the overall development of traditional economic activities must be determined with due consideration being given to the zonal economic and natural characteristics of our country and also in conjunction with general economic regionalization" (Reference 5, p. 162). However, even here, in spite of the presence in the book of a special chapter on the "Special zonal features in the development of the hunting economy", nothing is said about a natural-zonal approach to the management of the hunting economy. For the hunting economy the authors try to adapt, without making any changes, the economic regionalization that was devised for completely different purposes.

The general economic regionalization of the U.S.S.R., devised

essentially for the needs of industry and large-scale agricultural production, is inapplicable to those sectors which are based on the utilization of the wild biological resources. Within any region biological resources correspond to its natural conditions. Consequently, as long as a correct natural differentiation is not carried out within the territory of the taiga, it will be impossible to achieve proper development of the traditional economic activity in the taiga.

The subdivision of the taiga into northern, central and southern subzones has been practised in science for at least two to three decades. There were even some doubts about the zonal homogeneity of the inadequately known northern taiga zone as such(16). Biogeographical and biological-economic studies in Western and Central Siberia(9,12,13) have confirmed the need for a zonal subdivision of the taiga both in terms of its animal population and in the light of biological-economic planning.

Traditional economic activity has up to now predominated throughout the main part of the taiga zone. Since the traditional economic activity of the taiga is almost completely based on utilizing wild biological resources, it is natural that it should vary considerably in different subzones since the types and amount of the resources providing the raw-material base for the economy are different within them. The possibilities and expedience of developing various sectors of the taiga economy are different, for example, around Igarka and on the Angara, although in both cases we are speaking about taiga.

In the biological-economic respect the taiga can be considered even less as a single unit than it can in the physical-geographic sense within which one could adhere to a single system of managing the economy. The northern, middle and southern taiga are no less independent in a biological-economic sense than are, for example, the tundra and the treed tundra. Consequently, we consider that the time is ripe to talk about the presence, within the territory of the taiga, of three independent biological economic zones: the northern taiga, the middle taiga and the southern taiga. The biological-economic zone of the northern taiga in turn can be subdivided into two subzones: the far-northern taiga and the typical northern taiga(11,12,13). Brief descriptions of biological-economic zones of the taiga are given below. The description of the biological-economic zone

of the northern taiga is given separately in the form of descriptions of the two subzones of which it is composed, in order to stress the special nature of each one of them.

Biological-Economic Zone of the Northern Taiga

(a) Biological-economic subzone of the far-northern taiga. This is clearly discernible in our northern reaches, at any rate in the European part and in Siberia from the Urals to Yakutia. It entends from north to south over 60 - 200 km. In Western Siberia it more or less corresponds to the subzone of spruce-larch forests of G.V. Krylov[6]. The duration of the frost-free period is 75 - 80 days, the spring change to a daily average temperature of +10° occurs during 15-20 June, the sum of active temperatures above +10° is 600 - 900°.

The timber stand is very sparse, the trees have thin trunks, which are twisted and have a spiral grain. The yield of industrial wood as a rule is pitifully small and often does not meet even the local needs. More dense forests can be found only along river valleys and in lake hollows. According to data for the spruce stands in the European North the forests here are classed as V(a) - V(b) quality class. The timber stand is 40 - 60 m^3/ha, annual increment is 0.2 - 0.5 m^3/ha[7]. The figures for Western Siberia are similar. The annual increment on the average for all forests is 0.4 m^3/ha. The stand is not more than 20 - 30 m^3/ha. Centralized logging is completely unjustified.

Marshes are well developed with an area greatly in excess of forest-covered areas, especially in Western Siberia (the area of marshes constitutes 84% of the subzone territory, while forests cover 12%).

The special feature of Western and Yenisei Siberia is the absence of pine groves, which are widely present in the typical northern taiga zone. Siberian pine is found in small numbers but good nut-bearing years are infrequent. From among the wild food plants in good years there are considerable

yields of low-grade mushrooms and the berries including wortleberries and cloudberries. Cowberry stands cover small areas; these are found in a mosaic pattern and are poor in terms of productivity.

The far-northern taiga provides better protection and food-producing conditions than the treed tundra. Here an almost complete range of typical taiga animals can be found. The population of the majority of taiga species is so sparse that the development of hunting as an important economic activity is not always possible. For example, according to our observations carried out in the Yenisei basin, the average number of sables in the subzone does not exceed five per 100 km^2. Within the valleys of the major rivers and in the treed tundra there is a predominance, not of taiga, but of migrating tundra species, for which the far-northern taiga is the wintering ground (reindeer, arctic fox, and ptarmigan).

Since there are large areas of reindeer lichen it would be advisable to foster reindeer breeding. The role of reindeer breeding is very important to hunting. Since the ranges are not very productive and the numbers of game and fur-bearing animals are small, the hunters must cover wide areas, which is not possible without the use of reindeer or aircraft. The usual size of a hunting range is 300 - 400 km^2.

The subsidiary agriculture for personal needs of the residents (potato growing, with not fully-developed tubers, and dairy farming) is possible to a limited extent in valleys of the major rivers (the Ob, the Yenisei).

(b) <u>Biological-economic sub-zone of the typical northern taiga.</u> It extends from north to south over a distance of up to 400 km. The frost-free period is 80 - 95 days. The spring change to an average daily temperature of +10° occurs during 10 - 20 June. The sum of active temperatures over +10° is 900 - 1,200°.

The forests are sparse. The stands are of V, less often IV quality class. The stand per ha is 80 - 120 m^3 for spruce in the European North; on the

average for Western Siberia it is 60 - 80 m^3, occasionally reaching 100 - 130 m^3(14). The annual increment in the spruce forests of the European North is 0.6 - 1.2 m^3/ha, in the forests of Western Siberia, on the average 0.6 m^3/ha(6). It is possible to do selective logging to meet local construction needs. Centralized logging operations would not be advisable.

Marshes are less frequently found here than in the far-northern zone (in Western Siberia 70% of the territory is marsh and 29% forest-covered). Low-grade pine groves are abundant and they are to a great extent reindeer moss-bearing. Occasionally one can see Siberian pine stands (in Western Siberia they amount to 13% of the forests). Approximately 1 - 2 times every 10 years commercial collection of nuts is possible. Considerable areas are covered by cowberry which yields 25 - 30 tons/km^2, but they do not bear fruit every year. Nevertheless, cowberries here constitute the principal crop for gathering. Bilberry is less frequent and bears fruit less often. There are plentiful yields of wortleberries and cloudberries, and also of low-grade mushrooms.

In the areas where there are sufficient quantities of reindeer lichen it should be possible to develop reindeer breeding of the taiga type without distant seasonal drives. Reindeer transportation retains its importance for the hunting industry.

Hunting based on local, taiga species can be developed as one of the basic sectors of traditional economic activity, although the number of animals is, as a rule, rather low. The main species are squirrel, sable in the eastern regions, muskrat and ermine along the valleys of the main rivers. Migrating tundra species (arctic fox and ptarmigan) in some years play an important role in the hunting industry. The size of an individual hunting range amounts to 200 - 300 km^2.

A limited development of subsidiary vegetable growing is possible (potato, cabbage) and dairy farming.

Biological-Economic Zone of the Middle Taiga

It stretches from north to south 350 - 500 km. The length of the frost-free period is 95 - 100 days. The spring change to a daily average temperature of +10° occurs during 20 May - 10 June. The sum of active temperatures above +10° is 1,200 - 1,800°.

Well-developed forests are of quality III - IV, and in individual cases even II. The timber stand is 100 - 160 m^3/ha. The annual increment in the European North is 1.8 - 2.0 m^3/ha, in Western Siberia on the average 0.8 m^3/ha.

The area occupied by marshes is less than that of forests (in Western Siberia the marshes occupy only 46% of the area and the forests 49%). Pine groves are widespread, including lichen and green-moss groves (in Western Siberia 38% of the forest area). Siberian pine areas are also considerable (in Western Siberia 28% of forest-covered area). Approximately four times every 10 years the yield of Siberian pine nuts is sufficiently good to organize harvesting. Large areas are covered by high-yield berry fields (cowberry yields reach 50 - 60 tons/km^2; bilberry 35 - 40 tons/km^2. In the southern reaches of the zone there are considerable quantities of cranberries.

The hunting ranges are productive. In Eastern Siberia the gross yield from pelts has been 158.9 rubles, and the harvest of game birds, 46.3 per 100 km^2[(10)]. It is possible to hunt on foot without long distance treks or use of reindeer transportation. The average area of a hunting range is 100 - 150 km^2.

Vegetable growing is possible almost everywhere (potato, cabbage, root vegetables), and in places it is possible to sow grains (for feed). It would be advisable here to develop dairy animal breeding.

The Biological-Economic Zone of the Southern Taiga

The zone extends from north to south over 300 - 350 km. The duration of the frost-free period is 100 - 105 days, i.e., a month longer than in the

far-northern taiga. The spring change to an average daily temperature of +10° occurs during 15 - 25 May. The sum of active temperatures above +10° is 1,400 - 2,000°.

The forests are usually of quality II - III, less often I and IV. The trees are well developed and yield high-grade wood. The stand per ha amounts to 160 - 220 m^3 in the European part and 110 - 150 m^3 in Siberia; the average annual increments are respectively 2.1 - 3.5 m^3/ha and 1.5 - 2.0 m^3/ha. The southern taiga pine stands (for example the Angara Basin pine stands) provide excellent export quality wood. The Siberian pine forests have high yields. The gathering of Siberian pine nuts is recommended 5 - 6 times within every 10 year period. The main berry gathered is cranberry (yields of 30 - 50 tons/km^2). There are frequent occurrences of cowberry (yields of 40 - 50 tons/km^2), and bilberries (yielding 40 - 50 tons/km^2). The mushroom yield of the forests is also high.

In the southern taiga it is possible to keep bees, mainly on the basis of burnt-out willow-weed areas.

The productivity of hunting ranges is even higher. The gross yield from pelts for Eastern Siberia is 270.7 rubles, and harvest of game birds 107.9 per 100 km^2[10]. The average size of a hunting range is approximately 100 km^2.

The southern taiga is potentially suitable for a wide-scale development of agriculture (vegetables, potatoes and grain) and animal breeding.

Descriptions of the biological-economic zones and subzones of the taiga given above show that hunting and agriculture, based on the natural characteristics and possibilities of the territory, should develop differently. In all cases, as always with the traditional economic activities of the north, it should be carried out in an integrated manner, i.e., based on the development of not one but several - two or three - leading sectors[11]. The selection of leading sectors for the various taiga territories would differ primarily depending on the type of biological economic zone to which they belong, and secondly, depending on the

geographical region in which they are located.

The possible combination of leading sectors of traditional economic activities, and also some forestry and agriculture, for the biological-economic zones and subzones of the taiga in the European North, in West Siberia, and in the Yenisei north, are given below.

In the subzone of the far-northern taiga: 1. fishing, on the lower reaches of the main large northern rivers; 2. reindeer breeding; 3. in some regions hunting, based primarily on the tundra species which migrate here in the winter; 4. some gathering of mushrooms, currants, bilberry and cloudberry.

In the subzone of the typical northern taiga: 1. hunting; 2. in places reindeer breeding and fishing; 3. some gathering of mushrooms and cowberries; 4. in the valleys of large rivers, subsidiary agriculture.

In the middle taiga zone: 1. hunting; 2. in places logging; 3. large-scale gathering of mushrooms and cowberries; 3. to a lesser extent gathering of bilberries, black currants and Siberian pine nuts; 4. subsidiary agriculture.

In the southern taiga zone: 1. logging; 2. hunting; 3. gathering of wild food products (mushrooms, Siberian pine nuts, cranberry, cowberry, bilberry, black currants, etc; 4. subsidiary agriculture; 5. in places bee-keeping.

From the above it can be seen how sharply the selection of taiga economic sectors changes and gets richer as we move from north to south. It is absolutely clear that we cannot talk of a single system of economic management for the taiga.

We have given almost exclusive consideration to the zonal features of carrying on traditional economic activities in the taiga. Of course the differences between the individual areas of the same biological and economic zones and subzones are of considerable importance. For example, the combination of economic sectors which could be recommended for the typical northern taiga of the European

North, will no doubt be different from that suitable for the typical northern taiga of Western Siberia.

The scope of the present article does not include the detailed analysis of the regional biological-economic subdivision of the taiga nor a description of the subdivisions thus obtained. This would be the subject of a special study which must be carried out on the basis of the biological-economic regionalization of the Soviet North. Such regionalization was proposed by E.E. Syroechkovski[12]. On the basis of regionalization it would be possible to compile biological-economic characteristics of delimited regions, characteristics of biological resources, and the existing traditional economic activities complex (or of an economic complex as a whole based on the utilization of the wild biological resources, including the forest resources), and it should be possible also to define the type of complex which could be recommended for development within this region in the future. As a result of the compilation of such characteristics the border lines between individual delimited areas would be more precisely defined, and the validity of the biological economic subdivisions proposed above for the territory of the Soviet North would be demonstrated.

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II. REGIONAL FEATURES OF NATURE CONSERVATION IN THE NORTH

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THE POSSIBILITY OF TRANSFORMING NATURE IN THE WEST SIBERIAN NORTH

Some natural features. Certain processes are taking place in the West Siberian North which adversely affect the conduct of economic activities. Primarily these are spontaneous swamping, which leads to the destruction of the taiga, and the southward retreat of the northern forest boundary. Spontaneous swamping is attributable to a combination of factors: an excess of precipation over evaporation, the flatness of the relief, and exceedingly poor drainage. Under these conditions moss grows intensively, retains large quantities of water, as a result of which the soil is oversaturated and cooled, permafrost is formed, especially in the northern taiga regions, and soil aeration is hindered. In the final analysis all this means the destruction of the forest, the accretion of the mossy-peaty layer and the formation of peaty wasteland in place of forests and sparse forests[3,4,9,11,13]. Throughout the world there have been many examples of large subsidences of the earth's surface (up to 10 - 12 m) at the sites of oil wells and artesian wells as a result of oil-pumping operations[5]. It is not impossible that such an event could occur in West Siberia, and therefore preventive steps should be worked out now. Approximately 90% of the heat resources of the climate are expended on the total evaporation in the taiga, wooded tundra, and tundra zones (Reference 3, pp. 254-5). It has been calculated that for normal plant growth it would be necessary to remove 3,000 - 4,500 m^3 of water from the soil in an area of about one hectare. Then the overexpenditure of thermal resources would diminish by 4 - 6 kcal/cm^2 during the summer on evaporation, and this heat would be used to warm the soil and the surface layer of air (Reference 3, p. 255).

Problemy Severa, (18): 87-99, 1973.

The swampiness of the soils in the wooded and southern tundras is connected with the wide development of thixotropy.

The wooded and southern tundras, i.e., the belt of relatively treeless tundra[7], is characterized by unique vegetation cycles: in the islands of sparse larch forests an accretion of mosses takes place and a mossy-peaty layer is formed, which has an adverse effect on the hydrothermal regime of the soil, thus causing the trees to die. Spotted tundras often form in place of sparse forests, which later may be overgrown again with sparse larch forests[8,9,13]. But regrowth does not always take place. Larches are monoecious, wind-pollinated plants: the more sparse the tree stand, the lower the percentage of full-grain seeds[10]. Germinating seeds are usually scattered near the trees. Therefore, self-renewal of destroyed larch islets, especially those separated by distances of several hundred meters, is a rare occurrence. The cutting down of trees and large shrubs, the trampling of grass, shrubs, and lichen by domestic reindeer intensify the degradation of forest islands, thus causing the arboreal vegetation to retreat southward. However, since this is in no way connected with climate deterioration, by adopting a land improvement scheme and by careful treatment of the soil and vegetation cover, it would be possible not only to halt this process, but to advance the limits of arboreal vegetation 150 - 160 km further northwards, i.e., to approximately 68°N (Figure 1).

High-temperature permafrost (±0°C) is a very important factor in the conduct of economic activities in the northern taiga and the wooded and southern tundras[2]. The development of this land and the accompanying unavoidable changes in the soil and vegetation cover and the redistribution of the snow, disturb the heat exchange between the atmosphere and the soil, and consequently promote degradation or aggradation of the permafrost. Tree and shrub stands, which distribute the snow uniformly, can result in the formation of taliks in the southern tundra, while in the wooded tundra they could bring about the complete degradation of the permafrost and subsequent improvement of the environmental conditions, including higher soil and air temperatures, less swampy conditions and moderation of the wind force in tree stands.

From this it is evident that the West Siberian North holds out good

prospects for the transformation of nature and the improvement of environmental conditions. Here it is possible to change the soil and vegetation cover, to regulate the temperature of the permafrost, and to advance the growth of arboreal vegetation into the tundra, and so on. Any exploitation of resources involves a simultaneous transformation of nature. Our task is to try to find ways to transform nature in the West Siberian North in a rational and purposeful manner. The present article is devoted to this problem.

A brief description of the terrains. The concept of the complex territorial differentiation of the earth's surface, i.e., the variegation of the natural geographical conditions of its individual parts, is firmly established in Soviet geographical science. Therefore, any approach to the solution of questions relating to the rational exploitation of natural resources and the transformation of nature must be to some extent individually regional, i.e., in terms of terrain. The criterion for delimiting terrain as a basic taxonomic unit is its geographical individuality or uniqueness(1). The study of aerial photographs in conjunction with field observations has made it possible to identify a number of terrains, which we shall now consider.

I. The Khanmei-Kharbei terrain consisting of a glacial aggradation plain of the Zyryanka stage (Figures 1, 2). The background dominant terrain unit* is a plain (Figure 2, IA), formed mainly by fluvio-glacial (clay loam**, sandy loam***, more rarely sand) detrital deposits with peaty-gleyed soils, which thaw

* Terrain unit - "urochishche". This is a genetically homogeneous morphological part of a terrain which fully corresponds with the form of the mesorelief. Being an integrated natural-territorial complex, a terrain unit has at the same time a complex morphological structure and is subdivided into a series of facies. Facies usually assume the form of the microrelief or part of the form of the mesorelief. In a terrain facies the nature of the relief and moisture, the microclimate, soil variety, and plant community are all the same. In the North, where man's influence is not yet a major factor, facies and biogeocoenosis, identified according to plant community boundaries, occupy the same territory. In developed regions several plant communities may occur within a single facies.

** "Suglinok", conventionally translated as clay loam, is unconsolidated clay-silt-sand, earth material consisting of 10 - 30%, by weight, clay particles less than 0.005 mm, and having a plasticity factor of 7 - 17. (Transl. Ed.)

*** "Supes", conventionally translated as sandy loam, is unconsolidated sand-silt-clay, earth material containing 3 - 10%, by weight, clay particles less than 0.005 mm, and having a plasticity factor of 1 - 7. (Transl. Ed.)

in the summer to a depth of 45 - 60 cm under moss-yernik vegetation with sparsely distributed larch trees and larch forest islets; formerly occupied by sparse larch forests, now for the most part destroyed or dying as a result of the spontaneous development of mosses. The elevation of the plains is for the most part 150 - 180 m, occasionally 200 - 210 m above sea level.

The terrain facies (biogeocoenosis) of this unit are: 1) level, slightly convex or sloping sectors of small hummocky tundra with loamy peaty-gleyed thixotropic soils under moss-shrub-yernik vegetation; Siberian larches, 2 - 3 to 5 - 6 m in height, grow singly or in groups (small groves, islets) on these facies (they occupy approximately 50% of the unit); 2) identical level or slightly convex sectors, but occupied by spotted tundras, comprise 5 - 10% of the area of the unit; 3) small swampy depressions (diameter 5 - 10 m, depth 0.5 - 1.0 m), overgrown with moss and sedge, 5 - 10% of the area of the unit; 4) small thermokarst lakes, 10 - 15 m across and 0.6 - 1.5 m deep, water level only 30 - 80 cm below the soil surface, usually without fish, occupy 5 - 10% of the area; 5) runoff strips - usually small (0.5 - 1.5 m) depressions, overgrown with willow and dwarf birch.

The following unique anthropogenic facies are characteristic of this terrain unit: 6) "zimniki", i.e., roads used by the local inhabitants for travelling by reindeer-drawn sledges in the winter and often in the summer as well. These are wet depressions, 5 - 20 m wide, overgrown with sedge and cotton grass. When the cotton grass is in bloom these roads stand out as white bands, stretching for many kilometers into the distance. They also contrast with the backgrounds of yernik tundras and bogs; 7) in places where reindeer are slaughtered or where they have stayed for a long time, the vegetation is completely trampled down. Here the surface is a blackish-brown boggy mass of mud with pools of water, which, as a result of thermokarst, will deepen and merge into a single thermokarst lake; 8) thermokarst lakes have also appeared on the sites of geological prospecting pits, trenches, and boreholes (the more ice contained in the subsoil, the more intensively they develop); 9) wide muddy strips with pools of water formed in the tracks of tractors and general-purpose vehicles; on slopes they turn into thermokarst-erosion gullies, which develop in warm dry,

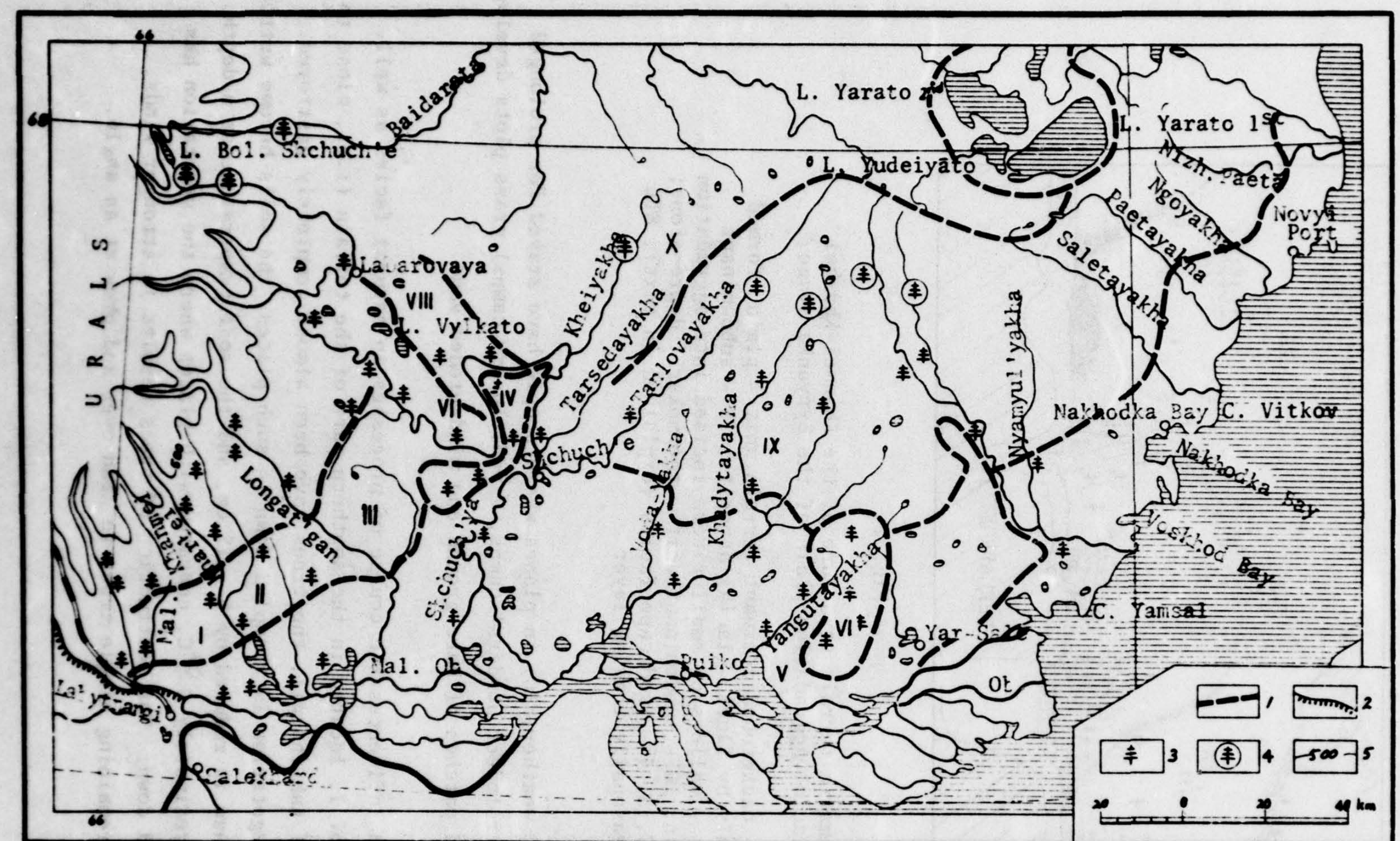

Fig. 1

Some terrains in the southern part of Yamal.

1 - boundaries separating terrains (I, II, XI); 2 - northern forest boundary; 3 - sparse larch forests and islands of Siberian larch in the tundra; 4 - northernmost limits of larch tree occurrence in river valleys; 5 - contour line 500 m

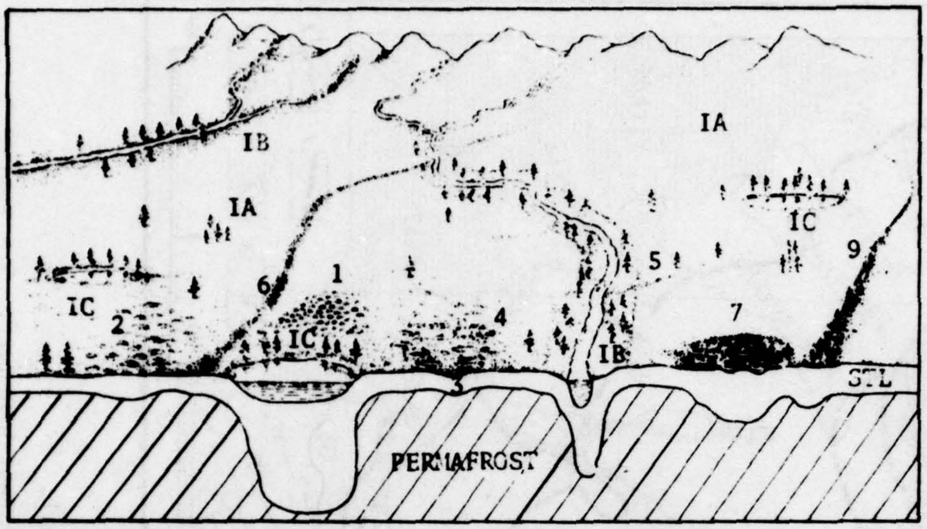

Fig. 2

Schematic terrain structure of the Khanmei-Kharbei glacial aggradation plain of the Zyryanka stage.

IA - background dominant terrain unit - plain, formed mainly by fluvio-glacial deposits; IB - subdominant unit - valleys of small rivers incised into aggradation plain; IC - subdominant unit - thermokarst depressions; 1, 2, 3, 4 - landscape facies (explained in text); STL - seasonally thawing layer

as well as rainy, weather; 10) in places where people have stayed for prolonged periods (nomadic reindeer herders' camps, expeditionary camps) grass plots develop with intermingled patches of bare ground and wind-eroded sand.

Man influences the course of processes in natural facies as well. Thus in facies No. 1, located in the southern part of the terrain (i.e., close to the settlement of Labytnangi), the trees have been almost completely destroyed. If the surface vegetation is trampled down in such places, the soils become wetter, their depth of thaw is reduced by 5 - 15 cm, and the soil temperature at a depth of 20 cm by approximately 0.5°C, compared with places where the vegetation has not been trampled down. The destruction of trees results in stronger winds, which force the remaining single trees to lean over and grow at an angle.

But here is an example of a beneficial effect of human activity. On one of the sectors (terrain facies 8) we came across four old, apparently prewar, trenches. They were situated parallel to each other, 5 - 6 m apart and approximately 20 m in length. The botton of each trench (about 1 m wide) was covered by water, while between the trenches there were dry areas overgrown with grass and young larches. In this sector, with a total area of about 400 m^2, there were no fewer than 30 young larches 0.5 to 1.5 m in height. The soil here was not only drier, but warmer than in the adjacent level swampy sectors. Thus, on 8 July, 1969 during the daytime the soil between the trenches thawed 60 cm; in the moss-yernik tundra the soil thawed 35 cm; the soil temperature at a depth of 20 cm was 6.0°C in the first case, and 0.7 - 0.8°C in the second case. This example suggests possible methods of amerlioration.

This sector of accidental land improvement is located within the dominant terrain unit of the Khanmei-Kharbei glacial aggradation plain. The remaining units are encountered within the boundaries of this terrain much less frequently. Subdominant units are valleys of rivers and streams incised into the glacial aggradation plain (Figure 2, IB). The depth of the incision increases from 10 - 15 m to 30 - 40 m westwards towards the Urals. The valley slopes are covered with dense yernik overgrowths (0.7 - 1.0 m high) with occasional larches. As in the plain unit, clearings here also occur frequently. The next subdominant unit comprises thermokarst depressions (Figure 2, IB), the slopes of which are covered by yernik-lichen and moss-shrub communities with sparse larch stands or individual larches, and the bottoms by flat-hummocky yernik-lichen-moss and moss-sedge bogs; there are usually shallow lakes in the centre of the depressions.

In the northwest, the Khanmei-Kharbei terrain is bounded by the Polyarnyi Ural foothills terrain, which is formed mainly of rocks of Paleozoic age. Here the river valleys, especially their southern slopes, are frequently covered with sparse larch stands. In the southeast, the Khanmei-Kharbei terrain is bounded by the coastal plain.

II. A new terrain begins on the left bank of the Karbei River. This is the left-bank Kharbei glacial aggradation plain of the Zyryanka stage, with residual coniform hills formed of Paleozoic rocks (Figure 1, II). The background

dominant terrain unit is a plain, formed primarily of fluvio-glacial deposits, similar to the same unit in the preceding terrain. The second background dominant unit consists of hills (round, ridge-shaped) formed by the original Paleozoic rocks and covered by a mantle of loose deposits (eluvial in the upper part, deluvial on the slopes), at the very bottom of the hills, glacial deposits. The remaining subdominant units are thermokarst depressions with lakes (the same as in the previous terrain (I), with sparse larch stands on the slopes, etc.) and valleys of rivers and streams.

III. The next terrain we shall consider is the Longot-yugan tundra (Figure 1, III) on a glacial denudation plain of the Zyryanka stage, covered with a thin mantle of loose deposits and lying close to Paleozoic rocks. Elevation is 230 - 250 m above sea level. The Longot-yugan River marks the boundary between terrains II and III. The background dominant terrain III unit is flat plain covered with loose deposits: a) with a large quantity of unrolled rocks, scattered haphazardly or grouped in rings, with facies of spotted tundras on elevated parts under lichen-shrub-moss tundras on tundra chestnut or gleyed soils; thickness of loose deposits 2 - 4 m; b) plains with a smaller quantity of stones and a thicker layer of loose deposits covering Paleozoic rocks. Here there are no stone rings, but spotted tundras do occur. Lichen-shrub-moss tundras predominate generally, hummocky tundras predominate in depressions (the hummocks are formed by sheathed cotton grass). The subdominant units are the valleys of small rivers and streams, which usually take the form of narrow steep-sided depressions worn in bedrock. On the crests of banks, i.e., the driest and warmest parts in the summer and the most exposed to winds in the winter, there are solitary clumps of Siberian larch. This indicates that the main obstacle to tree growth here is the swampy plain regime in the summer. The extremely harsh winter conditions on the crests of banks (strong winds and the absence of snow) do not appear to hamper tree growth if in the summer it is dry and warm in these places and the soil well aerated. The next subdominant unit is represented by valleylike depressions, the slopes of which are covered with yernik and the bottoms are swampy. The loose deposits in them are 8 - 10 m thick.

IV. To the north of the Longot-yugan tundra terrain is the wooded Sopkaiskii lake-hilly morainic terrain of the Zyryanka glaciation

(Figure 1, IV). The background dominant unit of this terrain is represented by moraine hills (Figure 3, IVA) of the most diverse shapes (rounded, elongated, crescent-shaped, etc.), formed by boulder-filled loamy sand, loam with sand layers underlying sparse larch stands with shrub alder and dwarf birch undergrowth on weakly podzolized soils with traces of gleization. The hills are 60 - 90 m, less frequently 100 m above sea level. Above 85 - 95 m the crests of the hills are usually occupied by spotted tundras. The relative heights of the hills vary between 20 and 50 m. The soil thaws to a depth of 80 - 120 cm; the subsoil contains little ice. The subdominant units of this terrain are depressions between the hills occupied by lakes (Figure 3, IVB) and valleys of rivers and streams (Figure 3, IVC). Whereas water is evenly distributed in the plain units of the Khanmei-Kharbei (I) and particularly the Longot-yugan (III) terrains, thus making them swampy, it is concentrated in lakes in the Sopkaiskii hilly terrain. Therefore, a considerable proportion of the heat, which in the first case is expended on the evaporation of moisture from swampy plains, is here expended on warming the soil and the air, a factor which is reflected in the comparatively rich forest vegetation. Better soil aeration is also a contributing factor. The animal resources are richer here: there are fish in the lakes, aquatic birds nest on the shores, ptarmigan and hares are plentiful, elks and bears are encountered. An evenly distributed snow cover prevents intensive freezing of the soil and, therefore, the soil temperatures here are higher than in other terrains.

If the first example, i.e., relatively rich vegetation in places drained by trenches (terrain I) is an isolated chance case, then the experiment conducted by nature herself, a forest amid tundra 80 km from the boundary of the forest zone confirms that in the southern tundra there is the necessary minimum of atmospheric heat for the growth and development of trees. It indicates that this atmospheric heat can be used by forest vegetation only in dry, drained places under natural conditions, primarily in natural geographic complexes with broken terrain. It is technically feasible to create a broken relief now, for example, by means of blasting. All that is needed is prior confirmation of the expendiency and economic profitability of such an undertaking.

V. We shall continue by considering younger terrains of a different genetic origin: firstly, the Panaevskii (V) (to the south of the

Fig. 3

Structure of the Sopkaiskii lake-hill moraine terrain of the Zyryanka glaciation.

IVA, IVB, IVC - terrain units (explained in the text)

Sopkaiskii) first marine terrace terrain (Figure 1, V). The background terrain unit is represented by flat areas composed of bedded deposits, mainly ice-rich loams and sandy loams with block (frost fissured) relief and a variegated vegetation cover - mosses, lichens, cotton grass, dwarf birch, alder, isolated specimens and clumps of Siberian larch and Siberian spruce. Larch and spruce along the bank of the Ob and in the region of the settlement of Panaevskii were cut down quite recently. The stumps, 13 - 30 cm in diameter, are well preserved; the annual rings clearly show their ages to have been from 70 - 80 to 150 - 180 years. The soils are peaty-gleyed. The subdominant units are, as a rule, thermokarst depressions with lakes and the valleys of small rivers and streams. The farther northward one goes, the deeper and wider the frost fissures, until eventually they become lakes.

VI. A few kilometres north of the Ob bank the nature of the terrain changes. Here begins the lake-hill terrain (VI) located between the Yanguta-Yakha and the Vary-Khaduta rivers (Figure 1, VI). This is the surface of the third marine terrace, in which intensive thermokarst processes are taking place. It is not impossible that the fissuring and subsequent thawing along the fissures is caused by a neotectonic movement of this sector. Lakes here are often of rectangular shape, following the contours of subsurface ice wedges; submerged in water along the shores of the lakes are dead larches, alder bushes and dwarf birches. In a number of places, zones of different ages of plant destruction can be traced – from quite recent specimens with preserved bark and even buds and individual pine needles to blackened trees, completely submerged in water or with their tops just visible above its surface. On the slopes of the hills of this terrain, Siberian spruce and twisted birch grow together with larch. The farther north, the more flat and low the hills become; the terrain becomes reminiscent of typical block mesorelief; the lakes become smaller and less numerous. The pattern of transition to terrain IX of the Kazantsevskii marine plain is approximately the same as on the southern boundary of this landscape.

VII. The alluvial-lake, hilly plain, Pevdei terrain (VII) situated on the left bank of the Shchuch'ya River (Figure I) is about the same. This is also a wooded terrain, the traces of thermokarst here are still more pronounced. Trees and shrubs which have died as a result of soil subsidence are encountered here, even on hills. The subsoil here is more than 50% ice.

Thus, one and the same pattern is characteristic of all the terrains: the formation of a hilly relief facilitates the draining of the soil surface and the accumulation of surplus moisture in lakes, rivers and streams, an increase in the soil temperature and the establishment of trees and large shrubs. All these factors taken together create favourable conditions for animal life in such areas – fish, birds, and mammals. And it is for this reason that such terrains are of interest as leisure areas and strictly controlled hunting, fishing, and log cabin holidaying.

VIII. The dynamics of the interactions of terrain facies and plant communities are of interest in connection with the present question of the

rational utilization and transformation of nature in the West Siberian North. Let us take the Khanovei terrain (VIII), a glacial aggradation plain of the Zyryanka stage, as an example of this dynamics, although the same kind of dynamics also applies to other terrains, viz., I, II, and IV (Figure 1). The background dominant unit of the Khanovei terrain is represented by low, frequently flat-topped hills, composed of boulder-strewn clay loam, sandy loam and sometimes sand. On the hilltops are found: 1) moss-shrub communities with sparse larch stands; height of larch trees 5 - 8 m; 2) approximately the same communities, but a thicker cover of mosses and old, dying larches, or completely devoid of trees; 3) moss-shrub communities with isolated patches of bare ground; 4) spotted tundras, where patches of mineral soil, devoid of vegetation, occupy at least 50 - 60% of the surface of the hilltop; 5) spotted tundras, overgrown with young larches, alder bushes and larch clumps; this community alternates with the one we referred to at the beginning, moss-shrub with sparse larch stands. This is a series of communities which periodically alternate with each other in time[8,9].

In the postglacial thermal maximum this terrain was evidently completely forested: traces of afforestation are visible right up to the Yarro-To Lakes and even slightly to the north of them. In outcrops on lake shores in the Khanovei terrain two-meter peat beds and well-preserved trunks of larch, spruce, and birch trees are encountered. The deterioration of the climate led to the destruction of sparse forests on the hilltops, the most unstable parts of the terrain.

A singular unstable equilibrium now prevails in the Khanovei terrain. The slow accretion of the peat-moss layer leads to the destruction of trees and large shrubs; the tree seeds cannot germinate in the thick peat-moss layer. The destruction of the trees and shrubs on the tops of the flat-topped hills results in the snow being blown away, degradation of the peat-moss layer, and the formation of spotted tundras in its place. The snow begins to find a hold and is concentrated on the tops of the slopes, where trees and alder bushes still remain. The moisture in the lower parts of the slopes increases and, if composed of loams, cotton grass-hummocky tundras are formed.

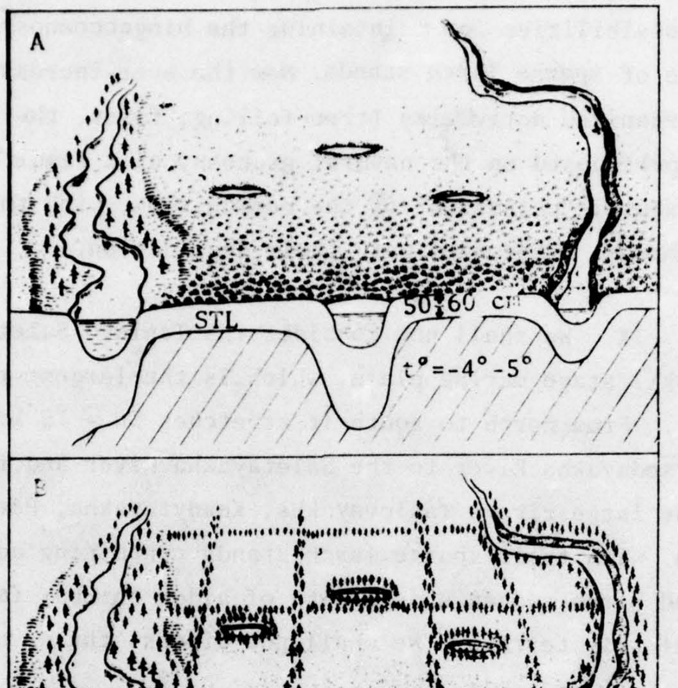

Fig. 4

Structure of the Tanlovo-Saletayakh marine plain terrain of the Kazantsevskii stage.

A - background terrain unit - flat areas formed of bedded (sandy and sandy loam, less frequently clay loam) deposits; badly drained, occupied by hummocky cotton grass communities; B - transformed terrain. The soil can be drained with drain pipes (D), as a result of which conditions would be created for a higher soil temperature, an increase in the depth of the seasonally thawing layer (STL), and tree growth. Permafrost degradation would be facilitated by tree belts. Meadows could be cultivated between the tree belts.

Under the conditions created by such an unstable equilibrium there are great possibilities for maintaining the biogeocoenosis in the optimal state - the state of sparse larch stands. Now the ever-increasing severe pressure of man's unorganized activities (tree-felling, fires, the trampling down of vegetation) is superimposed on the natural process, as a result of which the above-mentioned natural "pulsation" of the communities, with the participation of trees and large shrubs, alternates with their degradation.

IX. We shall now consider the Tanlovo-Saletayakha terrain (IX) of the Kazantsevskii stage marine plain, which is the largest terrain in the region (Figures 1 and 4). From north to south it stretches 50 - 75 km and from west to east from the Tarsedayakha River to the Saletayakha River and farther northeast. The valleys of the large rivers Tanlovayakha, Khadytayakha, Paesedayakha, Yakhadyyaka, and Khudievayakha, with their sparse larch stands containing admixtures of Siberian spruce and twisted birch and an undergrowth of alder shrubs, form the largest morphological unit of this terrain. We shall not discuss these valley terrain subunits.

The background terrain unit beyond the river valleys is represented by flat areas formed by bedded (primarily sand and sandy loam, less frequently, clay loam) deposits with a variegated lichen-moss-cotton grass plant cover on sandy chestnut, weakly gleyed and peaty-gleyed tundra soils. Small depressions are swamped (with a preponderance of moss-sedge vegetation); level parts are occupied by hummocky-cotton grass communities. This is observed even on sand, a fact which is indicative of extremely poor drainage, or the complete lack of any kind of drainage. There are no larches or alders on these flat areas and even dwarf birches occur only in small clumps. On the crests of slopes and small elevations there are usually wind-eroded sand foci.

Subdominant terrain units are: a) the valleys of small treeless streams and brooks, the slopes of which are overgrown with dwarf birch and willow; alder shrubs in such valleys occur singly; b) thermokarst depressions, the middle parts of which are usually occupied by lakes. Unlike the previously mentioned landscapes, ancient peat beds are encountered here very rarely.

There is a widely held point of view concerning the dating of ancient peat beds to Middle Holocene (thermal maximum) thermokarst formations[2]. If this is valid, then apparently in this terrain depressions in which peat accumulation could occur were rare.

It has been established by investigations that in the West Siberian North there are no thermokarst formations which developed before the climatic maximum[2]. They are of the Middle Holocene or later age. The micro-climatic and soil conditions on the slopes of these lake basins are identical to those on the slopes of similar basins in previously discussed terrains (I, II, V, VIII), but neither larch nor alder are encountered here. This can be explained by the fact that in this epoch of the postglacial climatic maximum there were none of these plants on the swamped flat areas of the Kazantsevskii Plain of the terrain (IX) under discussion.

It is conjectured that during the climatic maximum the July temperature exceeded that of the present era by 2.0 - 3.5°C[6], and the northward displacement of the subzones varied (according to different writers) from 50 to 300 and even as much as 500 km. The mean July temperature in this terrain is now approximately 10°C. This means that in the era of climatic maximum it was 12 - 13.5°C, i.e., approximately the same as the present-day temperatures for Labytnangi, Salekhard and Panaeva. On the outskirts of these places there are areas in which, as a consequence of the flatness of the relief, poor drainage and swampiness, there are no sparse larch stands. Therefore it is entirely logical to suppose that in the era of the climatic maximum the flat areas of the Tanlovo-Saletayakha marine plain terrain of the Kazantsevskii stage were even less dissected and more swampy than they are now, and, therefore, treeless.

X. The Kheyakha coastal plain terrain (X) of the Salkekhard stage is in many respects similar to the preceding one (IX), except that its plains are higher and more dissected. Larch in islands of sparse forest and clumps are encountered only in the Kheyakha and Tarsedayakha river valleys.

XI. The last terrain we shall discuss is the Yarro-To lake terrain (XI). The background units here are the inter-lake hills, the tops of

which are formed of sand, and lake-shore terraces. Communities of alder shrubs occur on hills and slopes. The bushes are 0.5 to 3.0 - 3.5 m in height. Here wind sand erosion foci are widely distributed. According to tales related by the local inhabitants, the hills were covered with reindeer moss several decades ago. In the spring and summer reindeer congregated here in search of wind-blown places to escape from the mosquitoes. They trampled down the vegetation and now wind erosion takes place all the year round. On hot windy days it is hard to believe that one is not in a desert, but on the tundra at 68°N.

In numerous places on wind-eroded hills relict peat beds up to 2 or 3 m thick can be seen. These contain many buried arboreal remains - larches with horizontal roots and birch (sometimes with well preserved white bark, excrescences, birch fungi). Many tree trunks are found on low-lying lake terraces. These can be used for firewood. The local inhabitants assert that several decades ago there were larches along the shores of the Yarro-To Lakes. In 1969 there were no larches here.

Possibilities and ways of transforming nature. Thus, for the growth and development of trees and large shrubs on the vast territory between the Ob and the Yarro-To Lakes the minimum amount of heat is available. This heat, however, is made use of only in certain terrains with broken relief, where excess moisture is concentrated in lakes. Here the large amounts of heat, which in flat swampy terrains are expended on moisture evaporation, are used to warm the soil and the surface layer of air. Favourable conditions are also created for soil aeration. This produces a marked effect by comparison with adjacent swamped plain terrains; trees grow where there is a broken, hilly relief, and not only is the vegetation richer, but the fauna is as well. The second conclusion to be drawn from the studied material is that the terrain complexes are vulnerable and extremely unstable: muddy strips develop in the tracks of cross-country vehicles, thermokarst erosion gullies form on slopes. In the majority of cases these effects are irreversible, thus indicating the need for a very careful approach to the problem of nature transformation in the North on the one hand, and a strictly differentiated approach on the other.

What should be done under these conditions? Experiments in the afforestation of West Siberian tundra should be initiated now. At the same time the instability of the terrain complex could be exploited to man's advantage. Successful experiments are being carried out in draining swamps but in the more southerly taiga of West Siberia(12). Line charges of ammonite are used to excavate trenches in swamped forests in the Tomsk Oblast. A field test of this method gave positive results(12). The same method could be used in the West Siberian North. But it is necessary to carry out a preliminary check, i.e., experimental modelling on a terrain complex, since the thixotropic nature of the soils and the possibility of thermokarst on clay loam ice-rich subsoils could completely nullify the effect of excavating drainage ditches. Obviously, on sand it will be more effective than on clay loam or sandy loam.

It is theoretically possible to use another method of removing excess moisture. It has been found that water migrates towards subsoils with lower temperatures. If pipes (with holes on top and at the sides) are laid in the lower part of the active layer, free moisture will flow down these pipes in the summer, thus draining the soil layer. This recommendation also needs verification.

There is yet another method of draining the subsoil in areas to be planted with trees. A 5 - 10 cm layer of crushed stone is placed on the bottoms of trenches in which the trees will be planted. Fertilized soil, often fully borrowed, is used for planting. This facilitates rooting and growth. Thus the trees will grow in fertilized, warm, dry and aerated soil.

The drainage of excess water in tundra areas always raises the soil temperature. To obtain a better effect, soil drainage should be supplemented by mulching with peat moss or soot to keep the soil warm during the growing period. Summer warming of the soil should be combined with winter insulation. This can be facilitated by accumulations of snow between the planted trees and shrubs. Drainage, summer warming and winter insulation of the soil, and the planting of trees and large shrubs result in gradual degradation of the permafrost: more intensive summer thawing, higher permafrost temperatures and, if these are close to $0^{o}C$, complete thawing. The feasibility of such a transformation of nature is shown in Figure 4 on the example of the Tanlovo-Saletayakha (IX) terrain.

The proposed scheme also needs to be thoroughly verified. This should be done with great care. Ice-rich subsoil may subside and thermokarst lakes form in places where positive effects are expected. An economic feasibility study should also be made for all work involved in transforming the nature of the tundra.

We know how strikingly the vegetation changes near high-arctic stations and nomad encampments, anywhere the soil is fertilized. Since the problem of utilizing waste in northern settlements is now very acute, the obvious and more desirable solution is to scatter the waste considerably further away from the settlements. This should be done in the winter, spreading the waste evenly over the tundra. One can expect a twofold benefit: settlements will be clean and an enriched green tundra will appear in the outskirts of the settlements.

Now that the instability and vulnerability of the tundra zone terrains is seen to be an indisputable fact, it is necessary to take meaningful and practical steps to put forward the question of nature conservation in the tundra and wooded tundra zones of the West Siberian North. To preserve the vegetation, especially the tree and shrub vegetation, of the West Siberian North, the southern tundra and wooded tundra should be classified as a botanical sanctuary. The problem of organizing the preservation of the northern treeline should be considered in the light of the development of the Resolution of the Council of Ministers of the R.S.F.S.R. of 16 May, 1959 "On the establishment of protective zones in the northern part of the forests adjacent to the tundra".

There is also a need to establish a zapovednik in the West Siberian North, which should include the following terrains: the Longot-yugan (III), bordering on the foothills of the Urals, the Sopkaiskii (IV), the Pevdei (VII), and the Khanovei (VIII). A study of the interrelationships between the unstable and mobile plant communities of the Khanovei terrain, for example, could provide the answer to the question of the dynamics of the northern forest boundary, which is now not only of academic interest, but a matter of national economic importance as well. Marginal zones of the reservation should be earmarked for experimental modelling under natural conditions and the establishment of biogeocoenological stations. Of course, it would be necessary to select two of the same kind of terrain complexes - two of the same kind of terrain facies or two

of the same kind of terrain units; one in a zapovednik (to act as a standard terrain complex), the other in an adjacent area, in order to conduct experiments and make comparisons with the standard in a zapovednik.

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PROSPECTS FOR DEVELOPING THE MARSHES OF KARELIA

The territory of the Karelian A.S.S.R. is situated northwest of the European plain and extends for 670 km south to north, mainly between 61^{O}N and the Arctic Circle. About 18% of the territory is covered with lakes, 31% of it is occupied by marshes and swampy forests, while most of the remaining area is arable farmland or is overgrown with nonmarshy forests.

The presence of large marshes on Karelia's territory is related to the geological history of that country. The most ancient crystalline rocks cropped out on the surface and the surface relief grew very rugged under the effect of Quaternary glaciation and the activity of fluvio-glacial water. Another contributing factor that was favourable to the formation of swamps was the cold and humid climate of the postglacial age.

Forest industries play the most important part in Karelia's economy, including logging and sawmilling, pulp and paper, wood products industries, etc. Nearly half the wood logged in the Republic is now processed within its boundaries. During the current five-year plan the capacity of the Kondopoga and Segezha pulp and paper plants, as well as that of other forest products enterprises will increase markedly, as a result of which their demand for wood will also rise sharply. On the other hand, because of the significant overfelling permitted over a number of years, by 1980 the estimated annual rate of felling in Karelia will not exceed 14,600,000 m^3. To satisfy the growing domestic demand for wood, as well as the demand for export purposes, it is imperative first of all to improve markedly the efficiency of forest, timber and residue utilization; secondly the productivity of forests must be increased by all possible means and the

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forested area must be expanded through forestation of wastelands, essentially marshes, which are major components of Karelian terrain. According to the data of G.E. Pyatetskii and V.M. Medvedeva[4], the area in Karelia covered by marshes amounts to 3,400,000 ha and that covered by swampy forests to 2,000,000 ha. This represents 37% of the area occupied by the forest reserves. It is evident that given the high percentage of swampy areas, forest amelioration should be the principal means for increasing the size and productivity of forests; moreover, this should include not only draining, but the sum total of the measures used in forest management to ensure large-scale production of commercial wood of high quality.

The reclamation of marshes and swampy areas is also of primary importance for further development of agriculture in the Karelian A.S.S.R. Given land-development stations equipped with modern technology, the conversion of marshes to tillable land or highly productive hay meadows with valuable stands of perennial grasses presents no difficulty and is more effective, from the economic viewpoint, than removing stumps on logged areas and subsequently cultivating an uneven terrain strewn with boulders. In the event of marshy lands being reclaimed, the water regimen of the soil can be readily regulated within the desired limits, whereas reclamation of mineral soils may involve substantial additional costs for artificial irrigation during the periods of drought.

Studies on individual swamp systems began in Karelia as far back as the 1930s but have been carried out mainly in the postwar years.

In the course of this research data have been obtained on the extent of swamps on this territory, on the types of marshes and the distinctive features of their geographic distribution, on their configuration, size, hypsometric position, vegetal cover and thickness, as well as on the main properties of their peat deposits.

According to the ecological principles adhered to in this paper, the marshes and swampy areas of Karelia are divided into three large groups: the low (eutrophic), the transitional (mesotrophic) and the high (oligotrophic) types. Each type is characterized by a corresponding water supply, composition

of the peat-forming associations of plants, degree of decay and chemistry of the upper peat-layer underacting with the vegetation.

According to the data available[4], Karelian marshes are divided into these types in the following manner (Table I).

Table I

Classification of Karelian marshes by types

	Southern zone		Central zone		Northern zone		Total	
	Thous.ha	%	Thous.ha	%	Thous.ha	%	Thous.ha	%
Low (eutrophic)	206	23	94	8	172	14	472	11
Transitional (mesotrophic)	497	54	530	42	522	42	1,549	45
High (oligotrophic)	215	23	628	50	556	44	1,399	44
Total	918	100	1,252	100	1,250	100	3,420	100

Eutrophic marshes occur in fluvial plains, on gentle slopes of terraces and in drain basins and troughs. They are supplied largely by ground water, and partly by surface drainage water with an increased mineralization. The vegetal cover is therefore dominated by herbaceous and herbaceous-hypnum associations, often including sphagnum mosses, that need relatively high contents of ash elements, particularly calcium and phosphorus.

In boggy water-logged marshes, sedges often predominate in these associations, while rushes, horsetail (*Equisetales*), bog bean (*Menyanthes trifoliata*), marsh cinquefoil (*Comarum palustre* L.) and other species characteristic of swampy grounds, are found in subordinate quantities. In the plant associations of heavily water-logged marshes the hypnum-moss mat develops very

vigorously, while the fraction of plants from the herbaceous story decreases. In the areas marked by a running-water regime, i.e., drained in the summer in a natural manner, there arise plant associations including an arboreal stage that is composed of spruce, pine and birch.

Transitional marshes are situated in depressions that are irrigated by soft ground water poor in calcium and magnesium carbonates. They may also form in the process of evolution of the marshes as the hard ground-water supply is replaced by atmospheric water. This in turn is the result of an increase in the thickness of the peat bed and the withdrawal of the biologically active layer of the bog from the sphere of influence of ground water. Marshes of the transitional type occupy 45% of the total swampy territory of Karelia, a circumstance due mainly to the extensive distribution in this area of acid soils poor in calcium carbonates.

Typical plant associations found in the marshes of the transitional type are composed of sedge varieties and sphagnum mosses with occasional small depressed pine or birch trees on the elevations of the microrelief. A limited number of herbaceous species and mosses characteristic of both eutrophic and oligotrophic marshes commonly grow amidst the predominant sedge-sphagnum cover. In those places where the water level in the soil drops significantly in the summer, there arise patches of arboreal vegetation consisting of pine and birch trees that may be interspersed with spruce.

Oligotrophic marshes commonly occupy areas irrigated mainly by soft atmospheric water. This accounts for the occurrence of oligotrophic sphagnum mosses in their vegetal cover as well as for the increased acidity, low rate of decomposition and low ash content of the peat formed. Marshes of this type are widely distributed in northern and central Karelia. The immense systems of swamps in the lowland adjoining the White Sea are represented almost completely by the oligotrophic type of marsh.

The surface of oligotrophic marsh massifs is commonly differentiated into the most markedly elevated elements (ridges) and pools*

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* Mochazhina - translated as "pools", is a wet, soft, hummockless area of a swamp. (Transl. Ed.)

between them extending perpendicularly to the water drainage from the swamp. Central regions of such massifs are often represented by complexes of small ridges and lakes.

The vegetal cover on the ridges is composed mainly of the oligotrophic sphagnum moss (*Phuscum*) and bog shrubs, such as wild rosemary or crustaltea ledum (*L. palustre*), blueberry (*Vaccinium* sp.), leatherleaf (*Chamaedaphe* sp.) and butterbur (*Petasites* sp.). Isolated trees or groups of trees also grow on the ridges. More markedly hydrophilic species of sphagnum moss predominate in the pools where they co-exist with a more or less well-developed herbaceous growth composed of cotton grass (*Eriophorum* sp.), scheuchzeria (*Scheuchzeria palustris* L.) and deer-hair (*Scirpus caespitosus*).

The peripheral zones of oligotropic marshes, where drainage is better, are overgrown with depressed pine stands.

The types of marshes characterized above do not necessarily exist as separate formations, but may be united into mixed marshy massifs that are composed of isolated patches represented by different types. Of particularly wide distribution are swamps in which the more markedly elevated peripheral zone is of the oligotrophic type, while the downwarped, commonly elongated central area is represented by the eutrophic or mesotrophic variety. These are the so-called peripheral oligotrophic swamps. Marshes of the "aapa"** type, the concave surface of which is characterized by a combination of flat broad "pools" of the eutrophic or meso-eutrophic type and of elevated ridges or "isles" represented by the mesotrophic or oligotrophic kind, are equally widespread.

The eutrophic, mesotrophic and oligotrophic types proper are interspaced by subtypes of marshes differing from the main ones in the composition of their vegetation and the acidity and chemistry of their peat soil. Information on the potential value of different types of peat soils is presented in Table II.

** Aapa - treeless bog with large pools, often with ridges and pools. (Transl. Ed.)

As may be seen from the above data, peat soils of the eutrophic type are characterized by low acidity, moderate or high ash content, and a significant content of Ca^{++} and Mg^{++} cations. These soils contain large quantities of total nitrogen and other nutrients required by plants. Eutrophic marshes are therefore of the greatest value for agricultural uses.

Peat soils of mesotrophic bogs have observably lower ash contents than those of the eutrophic type; they have a low concentration of bases and a more acid reaction. Their use in agriculture would require preliminary liming, fertilization and introduction of trace elements. Once drained, however, these soils would be quite suitable for forestation.

Soils of the oligotrophic marshes are characterized by a high acidity, low content of bases, a very small concentration of ash substances and a low rate of decomposition of plant remains. They are rather unsuitable either for farming or for forest culture. However, the nondecomposed or partially decayed surface sphagnum-peat could serve as excellent bedding for livestock or as raw material for industrial uses, in particular for manufacturing heat- and sound-insulating boards, for production of hydrolysis alcohol and furfurol, as well as for other types of chemical processing.

Marshes are distributed unevenly over the territory of Karelia. Their largest concentrations are located within the large ancient depressions, such as the Olonets, Shuya and Ladva plains, where peat bogs amount to 40 - 50% of the surface area. The largest eutrophic and mesotrophic marshes, measuring up to several thousand or even tens of thousands of hectares, are concentrated here. At the present time these marsh massifs serve as the principal object of land development for farming or forestation. In the Ladva plain the eutrophic and mesotrophic types of marsh massifs are associated with extensive excessively wet mineral-soil land, making these regions particularly promising for agriculture.

Many swamps of the eutrophic type (covering areas over 100 ha) with a relatively high ash content are situated in the Onega-Vodla plain of the Pudozh region.

Table II

Data from agrochemical research into peat soils * (in %)

Type of marsh	pH of salt extract	Content of bases	Total nitrogen	Ash	In dry substance		
					$CaO+MgO$	P_2O_5	K_2O
Low (eutrophic)	4.5-5.7	53-82	1.8-3.8	5.5-47.0	2.1-6.5	0.08-0.5	0.04-0.2
Transitional (mesotrophic)	3.5-4.9	30-39	1.8-2.9	4.1-5.6	0.6-1.7	0.08-0.14	0.05-0.12
High (oligotrophic	3.0-3.7	8-25	0.8-2.3	1.7-4.0	0.2-0.6	0.06-0.12	0.04-0.07

* The table was compiled mainly on the basis of the data obtained by V.A. Bukhman and M.M. Tsyba(2)

Because of the highly dissected relief in the Trans-Onega region, swamps are not extensive. It includes small marsh massifs with areas of up to 100 ha, but with deep peat deposits frequently underlain by sapropel. Eutrophic peat deposits of the palustrine or silvan-palustrine structure predominate. The ash content of the peat varies from 5.5% to 15%; moreover, alkali-earth elements and iron predominate in its composition(1). These swamp massifs also hold promise with respect to agricultural development.

In the regions marked by dissected relief combining moraines and denudation-tectonic ridges, a relief prevalent over half the total territory in Karelia, there are more complex systems of marshes forming a distinctive combination with numerous isles of well-drained land and residual lakes. Isolated systems of swamps extend here over tens of kilometers. The peat in these deposits is of the mesotrophic or eutrophic type with the rate of decomposition equal to 20 - 30%. Deposits of younger sphagnum peat occur essentially on the borders of the marshes or form the upper 50 cm-thick layer of the deposit. The ash content in the peat deposits varies from 4 to 6%. Flood-plain swamps are characterized by higher ash concentrations. Peat deposits of the oligotrophic type are relatively few among these massifs.

The territory of the Kostomuksha iron-ore occurrence in northwestern Karelia is one of such regions. In 1970, the Karelian Branch of the Academy of Sciences, U.S.S.R. carried out in this area integrated explorations in search of land suitable for farming oriented toward market gardening and dairy products. The explorations covered a fairly large territory marked by a relief that is composed of large ridges and hills alternating with areas of undulating moraine plain. The concentration of swamps in this territory ranges between 15% and 27%; small marsh massifs, measuring up to 65 ha each, predominate. Merging into systems, the marshes cover an area of up to 300 - 400 ha. The average thickness of peat deposits here is about 2 m, with a maximum thickness of 7 m. The most common types are mesotrophic and eutrophic deposits where sedge, scheuchzeria and cotton grass-sedge peats predominate. The mean rate of peat decomposition is 29% with the rate varying from 5% to 50%.

The territory of Kostomuksha forms part of a swampy region of the aapa type. Twenty-five to 30% of all the swamps found in Karelia are of the aapa type. Their vegetal cover includes associations of sedges, sedges and sphagnum or grasses and sphagnum in the centre, shrubs and sphagnum, often overgrown with trees at the periphery. The surface of the swamps is concave and displays a clearly defined longitudinal slope towards the water outlet (Figures 1 and 2). In view of the considerable surface gradient facilitating drainage, as well as because of the predominance of the eutrophic and mesotrophic types of peat, these marshes may be regarded as prospective tillable land.

The largest swamp region in northern Karelia is that adjoining the White Sea. In some parts of this region peat bogs cover 40 to 80% of the surface area. Only the narrow bands extending along the rivers and the elevations marked by outcrops of bedrock are free of swamps. Marshy massifs form intricate systems often measuring up to 15,000 - 20,000 ha. Peat deposits in the bogs are composed mainly of oligotrophic peat. The deposits vary from 1.5 to 8 m in depth[3].

Due to their enormous reserves of peat, represented essentially by the high-bog type with a low or medium rate of decomposition, the moors adjoining the White Sea are a region potentially promising for multipurpose exploitation of peat deposits for the economic needs of the Republic.

During the five-year period from 1971 to 1975, a total of 218,000 ha of marshes or swampy land forming part of the national forest reserves will be drained in Karelia. Furthermore, over the period 1971 - 1975 a total of 20,500 ha will be drained for agricultural utilization; this includes 10,000 ha where tile drainage will be applied.

We wish to stress the large scale of the projects that are underway. For example, in 1970 alone, 22,000 ha of forest land was drained, i.e., an acreage equal to that drained throughout the entire history of forest drainage in Karelia prior to 1966.

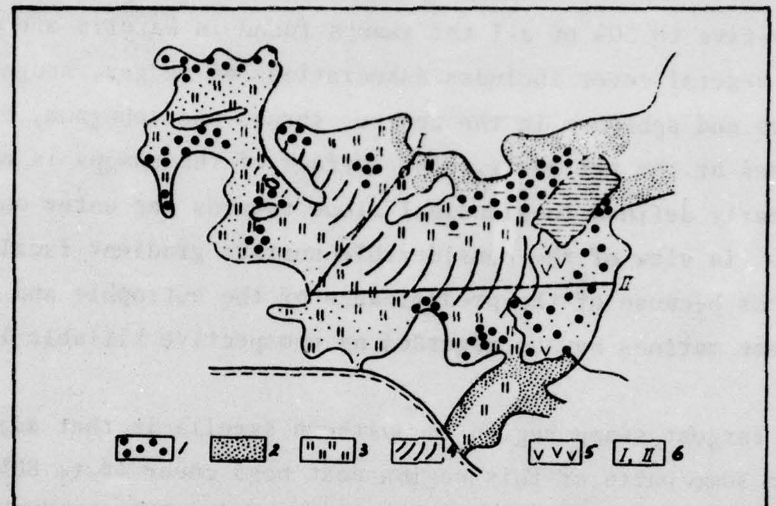

Fig. 1

Diagram of a swamp massif of the annular aapa type.

1 - meso-oligotrophic or oligotrophic sphagnum and pine stands;
2 - meso-oligotrophic shrub-sphagnum associations; 3 - mesotrophic grass-sphagnum associations; 4 - ridge-bog pool aapa complexes;
5 - mesotrophic sedge-sphagnum associations; 6 - profile sections

According to the estimates of the Forestry Institute of the Karelian Branch of the Academy of Sciences, U.S.S.R. and those of the Petrozavodsk Experimental Station(4), if the drainage of forest land projected for the nearest future is completed, the annual yield of timber from rejuvenation cutting in the swampy forests and along the drainage canals may reach 1,500,000 m^3. The projected additional annual increase in the output of timber from the drained territories in Karelia will eventually reach 7,000,000 m^3, i.e., nearly half the estimated present-day yield. It is possible to drain close to 2,700,000 ha of swampy forest land, and the additional increment would reach even more significant proportions in the future.

It is self-evident that in order to transform possibility into reality the whole complex of works employed in forest management and silviculture will have to be carried out in addition to drainage, including

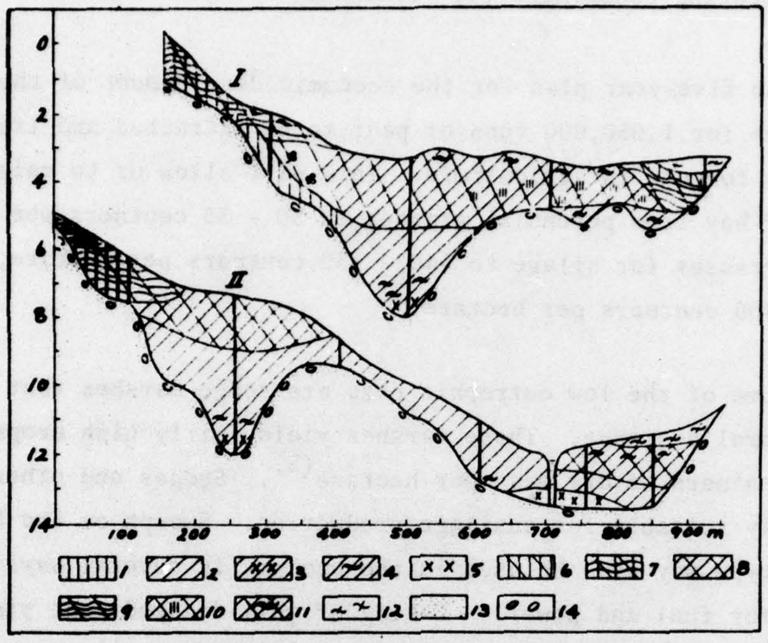

Fig. 2

Profiles of a swamp of the aapa type.

I - transverse; II - longitudinal

1-5 - *eutrophic peat*: 1 - wood peat; 2 - sedge peat; 3 - horsetail-sedge peat; 4 - sedge-sphagnum peat; 5 - horsetail peat; 6-11 - *mesotrophic peat*: 6 - wood peat; 7 - wood, cotton grass peat; 8 - sedge peat; 9 - cotton grass peat; 10 - bogbean peat; 11 - sedge-sphagnum peat; 12 - top phuscum; 13 - sand; 14 - rock

mandatory care of the drainage system, the cultivation of healthy tree stands, the use of fertilizers wherever they may be needed, etc.

The agricultural reclamation of low and partly of transitional swamps has already been developed fairly extensively in Karelia. Marshes of the aapa type are also quite suitable for this purpose(6). Further expansion of the farmland area, the development of animal husbandry and of a solid feed base require that works related to agricultural soil improvement be intensified and speeded up. Apart from being used for the cultivation of vegetables, root crops, annual and perennial grasses, the swamps will serve for peat extraction. The peat will in turn be utilized as fertilizer, bedding for livestock, or be

used for manufacturing containers for seedlings.

The five-year plan for the economic development of the Karelian A.S.S.R. provides for 1,050,000 tons of peat to be extracted and transported from the marshes for use in agriculture. This will allow us to raise the average yield of hay from perennial grasses to 30 - 35 centners per hectare, that of annual grasses for silage to 140 - 150 centners per hectare, and root crops to 350 - 400 centners per hectare.

Some of the low eutrophic bogs are sedge marshes that are subject to periodic natural drainage. These marshes yield fairly high crops of hay: up to 30 - 40 centners of dry mass per hectare[5]. Sedges and other swamp grasses are fully suitable for ensilage production. Swamps of the high (oligotrophic) type may also be used in the economy in several ways. The first application is for fuel and power. Coking of well decayed peat yields not only coke valuable for metallurgical processes and producer gas, but also products such as methyl alcohol, acetone, acetic acid, paraffin, wax, etc.

Deposits of poorly decayed peat may yield valuable raw material for the production of heat- and sound-insulating board, bedding for livestock (representing high-grade organic fertilizer after having been used in barnyards and cattle sheds), as well as antiseptic material for filling in cesspools in settlements where there are no sewers. Sphagnum peat is a raw material for hydrolysis yielding ethyl alcohol, protein yeast rich in vitamins, lactic acid, glycerine and other products. Glue made from rumic acids derived from peat is widely used in the manufacture of aspenite, in the woodworking industry and furniture manufacturing.

The swamps and marshy lands of Karelia, which had been regarded until fairly recently as its misfortune, are thus becoming its wealth at the present stage of economic development.

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PROBLEMS OF ENVIRONMENTAL PROTECTION IN THE KOLA NORTH

Numerous deposits of useful minerals with reserves having an All-Union or world-wide significance are concentrated in the Kola North. The development of these deposits has transformed the Murmansk district into an important raw-material base of our country. At the same time the Kola North is one of the major fisheries regions of the U.S.S.R. The resource-dependent nature of its economic development determines the increased concern for the rational use of its natural wealth, the proper exploitation of its renewable resources and the close attention paid to recreation in relation with the development of the mining industry.

The activites of enterprises in this industrial area invariably entail interference with the structure of the natural terrain. Many deposits of useful minerals are worked in the Kola North by the open-pit method of mining resulting in excavated areas, extensive tailing heaps and denuded wasteland, remaining bare of vegetation for many years.

The integrated use of mineral resources is one of the ways towards increasing the economic efficiency of industrial mining enterprises and reducing simultaneously their detrimental effect on the environment. This is particularly pertinent to the Kola North, where ores often contain several kinds of valuable minerals.

The greatest achievements have been recorded in the utilization of copper-nickel ores from which virtually all the valuable components are now

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extracted; moreover, the exhaust gases from the "Severonikel" plant are now used to produce sulphuric acid. Production of sulphuric acid has also been slated for the "Pechenganikel" plant. Technology has been developed for utilizing liquid-molten slag.

Until recently the Kovdor ores had been used exclusively for the extraction of iron. The construction of plant for the concentration of apatite and baddeleyite began in 1972. Once this plant is operational, the amount of waste will be sharply reduced. Furthermore, considerable quantities of high-quality apatite and baddeleyite concentrates will be produced from the masses of the rock mined.

The apatite-nepheline ores including, in addition to apatite, also nepheline, spene, aegirine and titanomagnetite, are used mainly for the production of apatite and, to a lesser degree, of nepheline concentrates. Meanwhile the raw material from which alumina and sodium carbonate products needed by our country can be produced is lost with the millions of tons of nepheline that is relegated to dumps at the present time. One of the advantages of nepheline as a raw material for sodium carbonate production is that it gives off no harmful waste, whereas the production of calcinated soda by traditional methods from sodium chloride is invariably accompanied by discharges of noxious wastes.

The problem of fully utilizing the Khibiny nephelines has been resolved in principle. A second plant for nepheline dressing is under construction in Apatity. Once the plant has reached its full capacity, all the nepheline extracted as a by-product will be concentrated. Moreover, a technology has been developed for extracting sphene and for producing titanium white, needed in the construction industry.

We are thus moving closer toward effecting the totally integrated utilization of both the apatite-nepheline ores and the polymetal ores from Kovdor.

Despite the progress made in the integrated use of mineral raw material, certain industrial mining enterprises continue heaping up dead rock in

dumps, while ore-dressing plants keep on discharging tailings in the process of flotation or during the dressing of ores by other methods. Filling natural or artificial settling pools or basins, the material of the tailings forms sandy or clayey-sandy evacuation surfaces. As the latter dry, they begin to be dispersed by wind.

Reclamation of land in the Murmansk district was not a serious problem in the past, since the land had little potential value to agriculture and was not intended for use in construction, while the aesthetic value of the terrain was lost once the dumps grew to become sections of man-made deserts.

Effective experiments in surface stabilization by sowing vegetation over the old dumps near Kirovsk may be regarded as an unqualified success in land restoration. The Arctic-Alpine Botanical Gardens of the Kola Branch of the Academy of Sciences, U.S.S.R. continues research in that direction.

Another method of storing waste is dumping it into lakes. Given the presence of over 110,000 lakes in this region, a small number of the lake basins can be converted to settling ponds or storages for tailings without particular detriment either to nature, or to people.

Purification of effluent water through settling (precipitation) is used as the main or accessory method at the "Apatite" plant, Olenegorsk dressing plant, and "Severonikel" nonferrous industrial combine in Monchegorsk. The bays of Lake Imandra, Monche and Belaya bays, near the shores of which these enterprises are situated, are used for this purpose. It is imperative to maintain a balance between the supply of waste and the capacity of the settling basins. It has been observed that fish have increased in abundance in the parts of the lakes located at a distance from the tailing storages.

As is well known, timber rafting is the main reason for pollution in a number of rivers. Rafting has recently been curtailed and in certain rivers, serving as spawning grounds for Atlantic salmon, it has been completely discontinued (Umba, etc.).

The Kola North has significant hydro-power resources, a large portion of which has already been harnessed.

Construction of dams for power stations causes a drastic restructuring of the natural regime in water bodies. For example, in Lake Imandra the range of natural fluctuations in the water level amounted to a mere 0.8 m; once the Niva cascade of power stations is built, however, the level of the lake may drop 3 - 4 m. The norms of permissible fluctuation in the level of water reservoirs have been calculated by the Gidrovodkhoz for the bodies of water located in temperate latitudes, where the main commercial species of fish spawn in the spring and where the winter lowering of the water level in the basin therefore does not affect fish stocks. In the North, however, the most valuable species of fish (all the Salmonidae and white-fish varieties) spawn in the autumn. When the level of the lake drops while the ice cover is still on (and this is the most common variant in the practical experience of hydro-power stations) the ice in the shallow spawning grounds (with the depth not exceeding 1.5 m) settles to the bottom and all the spawned roe dies. This may lead to a significant depletion of white fish, brown trout, cisco and other gourmet species of fish.

In view of the above, the technical solutions adopted must be reviewed with due attention to the specific aspects of the Kola North.

The construction of hydro-power station cascades on the Niva, Tuloma, Paya and Voron'ya rivers has made the migration of white fish to the spawning grounds difficult. Fish ladders on the Tuloma River proved to be rather ineffective.

The damage caused by the hydro-power dams to the reproduction of the Atlantic salmon is compensated to a significant degree by the network of fish hatcheries rearing juveniles of this fish. Moreover, pink salmon has been acclimatized in the water of the Kola Peninsula and Barents Sea, and its catches are beginning to acquire commercial significance.

The air is pure in the arctic regions, including the Kola North. In isolated cities, however, metallurgical industry, fossil-fuel power stations and various power installations continue to discharge into the atmosphere a certain quantity of chemical substances harmful to vegetation, animals and man.

In the light of the resolutions adopted by the September session of the Supreme Soviet of the U.S.S.R. the efficiency of the gas and smoke filters at the "Severonikel" plant must be increased. V. Ya. Poznyakov, the chief engineer of the plant, has initiated research into the effect of the plant on the environment.

Pure air in residential districts can be insured through a thoughtfully planned location of such districts in relation to industrial enterprises. Apatity, where the prevailing winds carry the smoke from the Kirovsk thermal power station away from the city may be regarded as a successful example of such planning.

About one third of the total territory in Murmansk Oblast is covered with forest, half of which is represented by scrub birch stands adjoining the tundra, and by forest-park zones around the cities. The rest of the forested territory is or was used for logging.

In view of the fact that both planting and cultivation of forests in the North requires a great deal of time, labour and capital, the balance between the cutting and reforestation has been partly disturbed. Under natural conditions a Northern forest completes its growth and matures within 100 - 150 years. It has been estimated that the forest reserves of commercial logging enterprises may be exhausted in the next 15 or 20 years if felling continues at the present-day scale. It is therefore planned to systematically reduce the allowable cut. The supply of forest products will meanwhile be increased through a more complete utilization of the spruce and deciduous timber and firewood, as well as of all the residues from timber logging and sawmilling.

It is particularly important that measures be taken to conserve the zones of forest-park and suburban woods.

The opening of through traffic on the Leningrad-Murmansk highway scheduled for 1974 may mark the beginning of a "tourist industry" both in Karelia and in Murmansk Oblast. According to the data from foreign sources, the income obtained from tourism in national parks of certain countries is 7 to 12 times the possible profit from the exploitation of the forests, pastures and rivers in those parks. Development of tourism is, however, unthinkable without conserving the beauty of nature. Tourism must be channelled along designated courses to avoid unorganized groups travelling along salmon-spawning rivers or across wildlife reserves.

Thanks to the activities of the Lapland reserve the stock of wild reindeer in the Kola Peninsula has been raised to the point where controlled hunting for reindeer was introduced. It appears expedient to sell reindeer hunting licences to qualified tourists.

It had been suggested a long time ago that national parks be organized in the region of Lovozero (Seidozero and the surrounding area), in parts of the Khibiny mountains and Sal'nye tundras. A national park regimen is the most appropriate form of management for the whole archipelago of the Solovetskie islands adjoining the Kola Peninsula.

It is a highly important development that the environment has become subject to long-term planning, a circumstance reflecting the immense advantages of the socialist system. A number of operative measures must, however, be taken parallel to long-term planning. These are measures aimed at preventing the pollution of water (for example, in Lake Imandra) and air in the growing cities. Land-reclamation projects must be urgently initiated within the cities and in their direct vicinity.

In order to facilitate planning of measures aimed at a rational utilization of nature, it may be recommended that Murmansk Oblast be divided into the following specific regions: a) the territories suitable for integrated economic utilization: b) inconveninent or the least valuable areas that may be used for storing waste, etc; c) resort zones near cities; d) protected forest zones or national parks; e) zapovedniki.

The total and integrated use of natural resources and environmental conservation in the Kola North would increase further the valuable contribution of this arctic region to the common cause of building communism in our country.

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A NEW FORM OF CONSERVATION AND MANAGEMENT OF NORTHERN TERRAINS

(Nature park [Prirodnyi park] in the Komi A.S.S.R.)

Modern technological progress is inextricably bound up with the increasingly more intensive utilization of natural resources and with the development of new territories. There are scarcely any significant territories left in Europe, with the exception of its northeastern part, where intensive man-made changes have not left their mark. The rate of industrial development is, however, increasing yearly even in the northern regions. Moreover, the trend is away from the selective use of natural resources and towards their total integrated development. This process is also clearly observable in the Komi A.S.S.R. Even now it may be stated with assurance that human activities have affected, directly or indirectly, the entire territory of the Republic.

Under the circumstances the protection or, more precisely, the conservation of unique ecological associations that may be used for scientific, cultural and educational, aesthetic or recreational purposes, becomes particularly important. The system of zapovedniki in the northern regions of our country does not reflect fully their environmental multiformity. Expansion of this system and creation of the eight additional zapovedniki provided for by the draft plan for the prospective geographic network of zapovedniki in the U.S.S.R.(4) also fail to solve all the problems.

In addition to zapovedniki, forms of conservation new to the U.S.S.R. such as nature parks, should acquire scientific and practical importance. Nature parks are intended to serve two purposes simultaneously: to conserve nature and to place the areas protected at the disposal of people for

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recreation.

The problems related to the identification and special preparation of the territories to be used for recreation (including tourism) are increasingly gaining in importance with every year. Progressive urbanization induces a steadily growing desire on the part of the city dwellers to spend their leisure time close to nature.

Developed terrain holds little attraction for tourists. They strive to visit relatively undisturbed corners of nature. The less developed a terrain, the more versatile and picturesque it is, the larger the numbers of the tourists wishing to visit the given region. Natural terrains thus act as tourist industry resources.

Until recently the absence of territories especially appointed for tourism was compensated for by the fact that the main flow of unorganized tourists was channelled to the zapovedniki. However, in the very near future the zapovedniki will no longer be able to absorb the steadily growing stream of tourists.

In the last few years the average annual increment of domestic tourism in our country amounted to 13%. Should it even remain at that level, by 1975 there would be 27,000,000 tourists in the country. The traditional tourist areas, such as Crimea, the Caucasus, central regions of Russia, can no longer absorb all those wishing to visit them. It has become imperative to identify ahead of time the territories capable of acting as tourist industry resources because of the unique nature of their terrains. The North has this capacity.

It is not enough, however, to identify the potential recreational areas; these territories must be excluded from industrial development and used for tourism by legislative means. This practice has become widely adopted abroad, where the territories thus set apart are referred to as "national parks". Following the suggestion of the Central Laboratory for the Protection of Nature, the term adopted for the territories of this kind in the Soviet Union is "nature parks".

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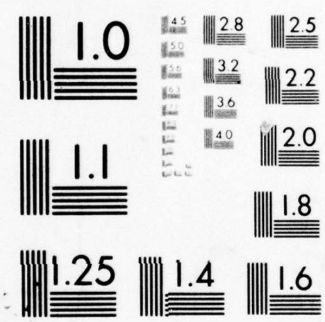

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Studies of the ecological associations in different regions of the Komi A.S.S.R. have shown that the terrains on the western slopes of the Northern and Subarctic Urals are of the greatest scientific, cultural-educational and recreational value.

The territory suggested for the nature park includes all the types of terrain characteristic of the Ural mountains and foothills, as well as a large number of natural monuments. Furthermore, it is delineated mainly by natural boundaries (such as water divides or channels). Its eastern boundary passes along water-dividing ridges and coincides with the administrative boundary of the Komi A.S.S.R. and Tyumen Oblast. Its northern boundary extends from the source of the Kozhim River to its intersection with the Kotlas - Vorkuta railroad line; thereupon it follows the railroad as far as the Kos'yu River and up the Kos'yu and Vangyr rivers. Its western boundary follows the primary and secondary tributaries of the major rivers flowing through the park, while its southern boundary coincides with that of the Pechora-Ilych State Reserve.

The surface area of the nature park enclosed within these boundaries amounts to about 17,000 km^2. The park includes three different orographic zones: the lowland (up to an absolute altitude of 200 m) constituting 7.5% of the park's territory; the spurs (up to 800 m) amounting to 42% of its territory; and the mountains (over 800 m) comprising 50.5% of the total territory of the park.

The Pechora lowland within the park represents a flat, in places a gently undulating terrain intersected by tributaries of the Pechora River. A characteristic feature of the lowland is the presence of poorly-drained areas in water divides and of numerous swamps. Its elevation increases toward the east, acquiring a more rugged relief.

A band of spurs extends along the Ural range; it attains the maximum width in the Northern Urals and virtually thins out in the Subarctic Urals. This zone represents a foothill peneplain raised on an average to 250 - 300 m and broken up by erosion into a number of north-south ridges overgrown with forest. Such elevations are referred to in the Komi language as "parmas". Individual

spurs composed of the most weathering- and erosion-resistant rocks, rise at up to 600 - 700 m (Ovin-Parma, Mertvaya Parma, Ydzhyd-Parma, etc.). The rivers crossing the band of spurs form numerous multiform picturesque denudations: crags, cliffs, etc. They are particularly numerous along the banks of the Ilych, Podcherema and Shchugora rivers. Limestone outcrops rising several tens of meters above the water level, are particularly impressive. These are the "Kirpich* Kyrta" (thus named because of its distinctive pattern of fissures and cracks and its brick-brownish colouring), the "Lez-Iz" and "Zamok"** crags (Figure 1), etc. Precipitous limestone cliffs descending to the water and referred to as "gates" are extraordinarily picturesque. These and many other formations not only offer purely aesthetic enjoyment, but are of interest to science.

The mountainous portion of the park is represented by the ridges of the Subarctic and Northern Urals.

The Subarctic Urals comprise the most intricately structured plexus of mountains in the Urals. In the centre they are composed of the Issledovatel'skii and Naro-It'inskii ridges which include the tallest peaks in the Ural mountains: Narodnaya Mountain (1,894 m), Manaraga (1,820 m), Kolokol'nya (1,721 m), etc. The relief in the Subarctic Urals is of the high-altitude type with distinctly defined alpine forms fashioned by ancient glacial activity and modern processes of frost weathering. The region is characterized by deep trough valleys, rocky peaks, sharply pointed crests, and cirques. The mountain slopes are covered with hillside waste. The corries and cirques enclose up to 25 glaciers[3] and numerous perennial firn basins feeding the rivers of the Urals.

The Northern Urals are a region marked by medium-altitude relief forms with gentle outlines. Altitudes commonly do not exceed 1,100 m with isolated peaks rising above that level. Tel'pos-Iz Mountain (1,617 m) is higher than the others. The relief of the most markedly elevated areas has formed under the effect of weathering. The region is characterized by picturesque outliers resembling pillars, towers, etc. Frost weathering has resulted in talus and placer

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* "kirpich" = brick. (Transl.)

**"zamok" = castle. (Transl.)

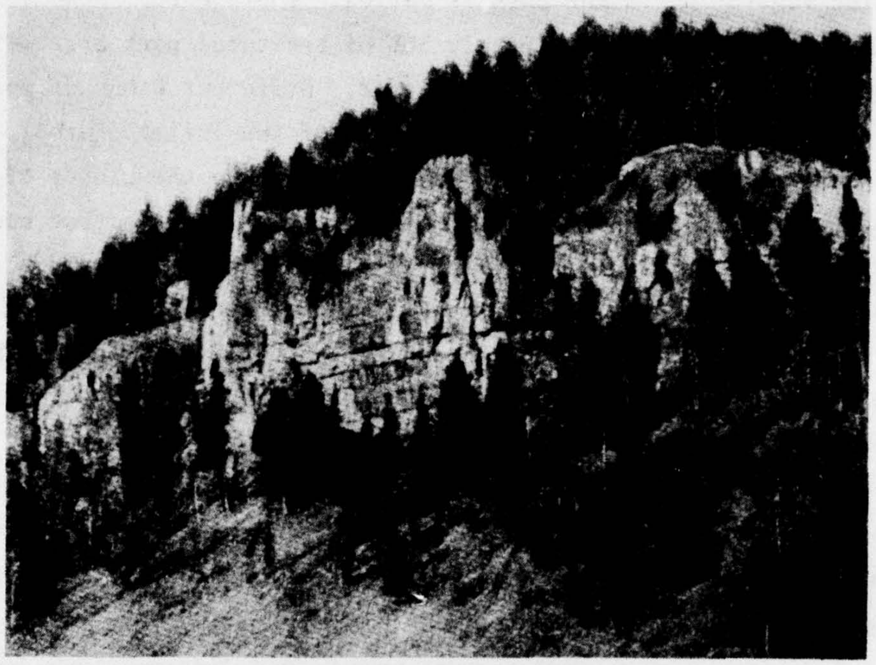

Fig. 1

"Castle" Cliffs. Photograph by V.P. Balibasov

deposits which cover the summits and the slopes and are composed of boulders called "kurumy".

The extensive distribution of readily soluble rocks (limestones, dolomites, gypsums) on the territory of the park results in the presence of diverse karst formations, such as caves, craters and dry river beds.

The altitudinal zonation characteristic of the mountainous areas in the park is responsible for a great topographic variety of the terrain. In the Subarctic Urals it is relatively easy to cross four topographic belts while ascending the mountains. At an altitude of about 300 m the mountain-taiga forests give way to a forest-meadow type of vegetation, which gradually changes at an altitude of about 600 m to a zone of mountain tundras. The latter is replaced by a mountain desert above the 1,200 m level.

The vegetation in the park is varied, represented, however, mainly by forests covering approximately 56% of the total park area. The main forest species are spruce, birch, larch and fir. Different kinds of spruce forests are the dominant type (covering over 70% of the forested area). Birch groves range second. Primary birch groves predominate on the slopes of the ridges; they are grouped near the upper forest boundary forming that boundary. Secondary birch groves arising after fires in lieu of the primary forests, are found in the park in the areas of spurs and plains. Larch grows on the territory of the park mainly in the mountains of its northeastern part, where it has terrain significance. It penetrates in the mountains to greater altitudes than any other species of trees and forms the upper forest boundary north of 64^{o}N. The northern boundary of the Siberian pine range passes through the park. The park encloses no pure Siberian pine stands, but its occurrence in spruce and fir stands may be significant (20 - 30%). The upper boundary of the forest descends from the south to the north (from 600 to 300 - 400 m).

Vegetation of the forest-meadow zone is represented mainly by thin birch and larch stands and by meadow tundras ("alpine meadows"); these are the most picturesque portions of the mountains. With increase in altitude birch and larch groves give way to sparse scrub-birch stands, thereupon to thickets of dwarf birch. The latter forms mountain tundras together with other shrubs, mosses and lichens.

The belt of mountain deserts (composed of bald mountains) bears no continuous vegetal cover; it forms islands amidst rocky placer deposits, hillside waste, perennial firn basins and small glaciers. Higher plants are lacking or are found in the form of isolated specimens.

The shrubs and forbs on the rocks in the mountainous belt and on the denudated limestones in the foothills are represented by varieties that are rare in the Komi A.S.S.R. and are therefore of great interest. These are single-berried cotoneaster (*C. integerrimus*), common shrubby cinquefoil (*Potentilla fruticosa L.*), green spleenwort (*A. viride* Huds.), common polypody (*Polypodium vulgare L.*), large-flowered lady's slipper, Siberian adonis (*A. sibirica* Patr.), etc.

The territory of the park ranks first among all the regions of the Republic with respect to the wealth of its animal kingdom. This is due primarily to the fact that the Urals occur on the European-Asian boundary; secondly, to the proximity of the large Pechora-Ilych State Wildlife Reserve. Bear, wolf, wolverine, fox, and lynx are common for this area; the forests abound in squirrel, marten, sable and ermine; muskrat has been satisfactorily acclimatized, the park abounds in capercailzie, hazel hen and grouse. Large numbers of water birds congregate during the summer in the bodies of water found in the park. In recent years moose have markedly increased in numbers; wild reindeer may often be encountered.

Numerous bodies of water lend unforgettable charm to the mountainous Urals. In high altitudes and at the points of intersection of ridges and spurs the rivers are turbulent with numerous rapids and bars. In the low altitudes and in the intermontane valleys the rivers acquire a semimountainous character; gravel or sand bars alternate with deep still reaches (referred to locally as "holes"*). Waterfalls may also be found here; one of the prettiest is the waterfall on Veldor-Kyrtael Creek in the "Verkhnie Vorota" ("Upper Gates") of the Shchugor River.

In some of the rivers the water is remarkably clear; for example, in the Shchugor River the bottom can be seen at a depth of over 8 m. Rapid rivers with rocky banks overgrown with thick forests combine into an unforgettable landscape.

The park encloses a multitude of lakes, the most picturesque of which are of glacial origin. As a rule, they are found high up in the mountains and are very deep (Tel'pos, Torgovoe, the group belonging to the Balban-ty system, etc.).

The bodies of water found in the park are not only interesting from the aesthetic viewpoint, but have a great scientific and economic significance.

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* "Yamy" (Transl. Ed.)

Most rivers in the nature park are spawning grounds of the famous Pechora salmon and are protected. Lakes and rivers are also rich in grayling (*Thymallus*), whitefish (*Coregonus*), "peled" (*Coregonus peled*) and brown trout (*Salmo trutta*).

The climate on the territory of the park (moderately continental) varies according to the altitude zonation. As the altitude increases the mean annual temperature drops from -2.5°C to -4°C and -6°C. The rate of precipation increases from 700 to 1,500 mm. The summer lasts for about two months in the Subarctic Urals. Early frost begins after August 20, and late frost ends in the early half of June.

In the Northern Urals and in the foothill area of the park the summer increases to 70 days. The temperature during the warmest month (July) varies from 15°C (in the foothills) to 10 - 12°C in the Subarctic Ural mountains. The winter is long (over 180 days), cold and with a great deal of snow. January is the coldest month. The average temperature in January varies between -19°C on elevations and -22°C in intermontane depressions. Under anticyclonic conditions the temperature in the mountains may be reversed resulting in a warmer temperature at the top of the mountains than at their foot. Abundant snowfalls in the mountains and drifting account for a snow cover occasionally exceeding 10 m in thickness. On the whole the climate in the park is wholesome, suitable for a resort area.

At present the territory of the park is not used for commercial purposes; its forests are mainly of the types forming part of a special reserve (pretundra, water-protecting, mountain forests, etc.); no mineral deposits of commercial value have been found in this area and there are no populated centres within its boundaries. Establishment of the park therefore would not be detrimental to any industries, but would allow us to conserve unique natural terrains and use them for recreational purposes.

The park is located relatively close to large industrial centres of the Komi A.S.S.R. (such as Pechora, Vorkuta, Inta, Ukhta, Syktyvkar) and has adequate communication with other parts of the country. The Kotlas - Vorkuta

railroad line passes along its northwestern boundary. The park can be reached by railroad in two days from Moscow, Leningrad or Sverdlovsk, or by plane on the same day.

Even now popular winter and summer tourist routes pass through the territory of the park. Most of them originate in the populated centres located along the Pechora River on the mouths of the mountain streams emptying into it, or at the railroad stations. Rivers are the only transportation routes making it possible at present to penetrate inside the Ural Mountains. According to partial data, the territory proposed for a park is visited even now by no fewer than 10,000 tourists a year. Tourists come here not only from nearby regions, but also from Omsk, Kemerov, Donetsk, L'vov, Tallin, Kishinev, etc. Trails of any degree of difficulty can be laid out through the territory of the park.

The lack of the most elementary facilities results in involuntary damage to the terrain by the tourists. They chop down trees along the Kozhim and other rivers in order to make rafts. Finding no deadwood, they cut down larch trees at the upper forest boundary. Some of the tourists fail to observe the dates of the hunting season and indiscriminately destroy wildlife. Not realizing that the rivers on their paths are spawning grounds of the Pechora salmon, the tourists catch its fry mistaking them for trout. This is detrimental to the reproduction of a most valuable species of fish. Establishment of the park would allow us to restrict and organize tourism, to conserve unique terrains, and the animal kingdom.

The territory of the park may simultaneously be used for sports. The fairly large number of hours of sunshine (particularly during the spring months), the long duration of the snow cover in conjunction with the diversified topography make it possible to build in the park sports bases and complexes, where athletes engaged in winter sports can be trained. Establishment of the park would also be of great scientific and cultural-educational significance. Unique monuments of nature that are subjects of research are located on the territory of the Northern and Subarctic Urals. They include stratotype sections of various geological systems (Ordovician, Silurian, Devonian. Carboniferous,

Permian, etc.) on the basis of which various problems related to the history of the formation of the Urals and adjacent territories may be solved. Crystal-bearing veins in the Pre-Ordovician metamorphic rocks occurring in the regions of the tallest peaks are highly interesting. There are numerous localities with buried fossil fauna and flora including guide forms important in stratigraphy. Parts of many limestone exposures are valuable to geologists as key or stratotype sections and to botanists as places where relicts can be found. The centre of mountainous glaciation, which geographers should continue to study, is located in the Subarctic Urals. The region of joint penetration of European and Asian fauna and flora species is of great interest to biologists. The diversity of terrains, relief, fauna and flora, the presence of geological key sections, and the large-scale denudation of geological strata may serve as a basis for establishing stations where students of geography, geology, biology, etc. would do their practical training.

As was mentioned earlier, the primary objective of establishing a park in this area is to conserve in their natural state the terrains representing tourist industry resources. The very idea of creating such units and the economic advantage obtained from them depend on the length of time during which the natural associations of the park will be preserved in their unadulterated state, i.e., on how long they can act as resources attracting tourists. In this sense one of the most vital factors on which the existence of the nature park depends is the assessment of its maximum capacity, i.e., the number of tourists the park can accommodate at any given time without detriment to its natural associations. At present there are no methods for measuring the resistance of different types of terrain to recreational loads. The preliminary estimates carried out by us with the use of the current standards and norms determine the simultaneous capacity of the park as equal to 30,000 people, i.e., 3,000,000 tourists a year. For comparison we wish to mention that the number of visitors to Yellowstone National Park in the U.S.A., having an area of about 9,000 km^2, amounts annually to 4,000,000 tourists, and to Great Smoky Mountain National Park (2,100 km^2), 6,000,000. Whether tourists will visit the Komi park in the numbers anticipated (a factor determining the economic viability of the park) depends on a variety of factors, including the organization and management of tourist facilities and services on the territory of the park, advertising, etc.

Even though the territory of the park is not used at present for commercial purposes, at some future date important mineral deposits may be found in its general area and the need to utilize its other natural resources may arise. We are facing the question whether the industrial development of this territory is possible and how it can be combined with the goals and objectives of a nature park. Experience of foreign national parks has shown that toal exclusion of industrial development ensures the best conditions for their existence. Nevertheless, in some resort areas certain types of minerals are mined, hydroelectric stations are built, agricultural enterprises are operating (for example, in our Estonian national park "Lakhemaas"). If need be, certain industries may be developed in a park, but on a number of mandatory conditions. First of all, the areas classified as forest reserves or reference terrain units (access to which should also be forbidden to tourists) must be left untouched by industrial development. Secondly, industry must never disturb the terrain as a whole. Thirdly, all uses of natural resources must be constantly controlled by the park administration.

At present, forests are the only known commercial resource within the boundaries of the park. According to data from aerial appraisal, the total timber reserve has been estimated as 100,000,000 m^3, which amounts to 3.5% of the total reserve of the Komi A.S.S.R. However, the forested area includes forests of the water-protecting zones along rivers with salmon spawning grounds (where commercial felling is prohibited by a government decree), of the pre-tundra forest-protecting zone (where no felling is allowed), as well as forests growing on steep slopes or those excluded from exploitation because of technological difficulties or the danger of erosion. According to our data, tree cutting is prohibited over more than half the total forested area of the park. The negligible reserves of commercial timber, removal of which would require large capital investments (particularly for construction of roads by which the timber can be transported, since rafting of the logs down rivers with spawning grounds is out of the question in any event), make the development of a logging industry on the territory of the park economically inexpedient.

So far there are no efficient methods for comparing the effectiveness of capital investments in the tourist industry with other sectors of the

national economy. Some economists believe that tourism is only a sphere of government expenditures. We agree, however, with the researchers[2,5] who maintain that the use of a territory for tourism is a highly effective form of economic activity. According to the data of P.G. Oldak, tourist industry resources in a number of Siberian and Far-Eastern regions (Baikal, Altai, Tuva, Kamchatka) to which we can add the Urals and other northern regions, have a considerably greater economic value than any other natural resource. According to preliminary estimates, returns of the capital invested for developing a territory into a park are 1.5 times faster than those recorded for the coal or oil and gas industries, and are nearly 2.5 times faster than returns from the forest industry in the Komi A.S.S.R.

The North of the Soviet Union has enormous tourist industry resources. To identify and take into account these resources is the most urgent demand of our time. Draft plans for instituting nature parks in Kamchatka, in Magadan Oblast and in other northern regions have already been worked out[1]. These regions undoubtedly enclose unique terrains and will attract large numbers of tourists.

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III. PROBLEMS OF RESOURCE DEVELOPMENT IN THE NORTH

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PROBLEMS OF FORMING INDUSTRIAL CENTRES IN THE EUROPEAN NORTH OF THE U.S.S.R.

In the Directives of the XXIV Congress of the C.P.S.U. on the Five-Year Plan for the Development of the National Economy of the U.S.S.R. for 1971 - 1975 it is pointed out that the intensification of production and increasing its efficiency constitute the main line for the development of the economy of our country both in the immediate future and for the long term.

In the light of these Directives the problem of systematic formation of territorial production complexes and industrial centres becomes very important, these being the most efficient form of territorial organization of the economy. It has been established that with a compact, group location of industrial enterprises an economy is attained in capital investments amounting to 20% and a reduction of production costs of up to 30%. This economic gain is achieved as a result of a fuller and more efficient use of the territory, raw materials, power and labour resources, construction base, transportation and engineering communications, which, through cooperation and integration of enterprises, become part of the territorial production complex. These were the reasons why the Directives of the XXIV Congress of the C.P.S.U. set a target: "To extend the practice of building industrial enterprises which would have common support and supply facilities, engineering installations and

* Central Economics Research Institute. (Transl. Ed.)

Problemy Severa, (18): 119-130, 1973.

communications".*

The formation of industrial centres and territorial production complexes should be done in accordance with a single programme, which would determine the basic stages and deadlines for the commissioning of mutually interrelated production plants in the main sectors of the national economy, as well as support facilities, and the service sector. In the course of this a greater amount of attention should be given to increasing environmental protection and improving the utilization of natural resources in accordance with the Resolution of the Supreme Council of the U.S.S.R. "On Measures for Further Improvement and Protection of the Environment and Efficient Utilization of Natural Resources" (September, 1972) and that of the Central Committee of the C.P.S.U. and the Council of Ministers of the U.S.S.R. "On Increasing the Protection of the Environment and Improving the Utilization of Natural Resources" (January 1973). In this Resolution provision has been made for the implementation of measures that would result in an improvement in planning and accounting in the field of environmental protection and the utilization of natural resources and an improvement in designing industrial enterprises and planning of cities and other human settlements. Specifically it is stipulated that in order to reduce the losses of valuable mineral resources in the course of their extraction and processing and to prevent environmental pollution by waste materials, ministries responsible for the production and processing of minerals must formulate, for all subordinate enterprises, planned measures to introduce more efficient methods and systems of extracting minerals, and technological systems of processsing the raw material, which would result in the most rational extraction of the mineral resources from the ground and utilization of those components contained in them which are of industrial value.

An analysis of the economics of individual territorial and production complexes and production centres has made it possible to analyse better the allocation of resources within any given territory, to identify the existing disproportions and shortcomings, and also to work out ways and means

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* "Direktivy XXIV s'ezda KPSS po pyatiletnemu planu razvitiya narodnogo khozyaistva SSSR na 1971-1975 gody" (Directives of the XXIV Congress of the C.P.S.U. on the Five-Year Plan for the Development of the National Economy of the U.S.S.R. for 1971-1975). Politizdat, 1971, p. 45.

for their elimination. V.I. Lenin has pointed out that "The importance of the location of industries demands grouping them in individual cities, suburbs, villages and groups of villages, which form industrial centres or regions".*

An industrial centre is a type of territorial production complex with an economic specialization, expressing its share in the territorial division of labour, formed (or being formed) on the basis of enterprises located on a relatively compact territory and possessing lasting economic links arising from the common use of natural and economic conditions. These include labour resources, natural wealth, construction, and fuel and power base, water supply, support facilities, engineering and transportation communications, and service sector, and occasionally a common technological interdependence.

An industrial centre is made up not only of industrial enterprises, but includes local farming and the entire infrastructure. An important special feature of an industrial centre is the location of a number of industrial facilities within a territory limited in size, which makes it possible to increase economic (and frequently also technological) links between them through integration and cooperation in production, through efficient utilization of the electrical network, engineering and technical communications, and which permits them to organize an efficient supply of heat and water.

In order to avoid excessive territorial spread and overloading the transportation system, the structure of an industrial centre should not be excessively diversified. At the same time it should ensure a harmonious combination of production and service sectors, thus creating suitable conditions for efficient employment of the population (both men and women).

The specialized sector of an industrial centre must be developed in conjunction with its other sectors. Consequently, the first task in the planning of an industrial centre is to set up a structure that would result in a balanced development of the leading, auxiliary, and support facilities. It is also equally important to ensure scientifically justified

* Lenin, V.I. Polnoe sobranie sochinenii (Complete collected works). Vol. 4, p. 33.

development of cooperation in production within centres. It should be borne in mind that a conveninent location with respect to transporation and geography makes it possible to utilize efficiently not only local but also raw materials from other sources.

The basic specialization of an industrial centre as a rule should correspond to the specialization of the industrial region in which it is located or it should complement the economies of other centres located within the limits of the region. In many cases the specialization of the principal industrial centre predetermines the main elements of the economy of the industrial region.

The presence of rich natural resources within the territory of the European North, the demand for which is continually increasing owing to the increasing rate of development of the national economy, has resulted in the growth of mainly extracting industries, such as logging, mining, fuel, fishing, and so on. This in turn has determined the nature of specialization of industrial centres in the European North, which are noted for having wood-processing, wood-chemical, mining, industrial-transportation types of centres.

Industrial centres in the European North have essentially grown during the years of socialist construction, and some of them are still in varying stages of development. They play the main role in the industrialization of the northern regions, in the formation of the territorial production complexes, and consequently also in the shaping of the entire economic complex of the region.

At the present time, within the European North, nine industrial centres have been formed or are being formed. These are: Murmansk, Khibiny, Petrozavodsk, Arkhangel'sk, Kotlass, Plesetsk, Syktyvkar, Vorkuta and Ukhta centres. The Ukhta centre is the base for the formation of the future large Timan-Pechora territorial production complex.

About two thirds of the industrial production of the entire European North is to be found in the nine industrial centres listed above. Each industrial centre has its own distinctive structural features, its own

historical conditions that have led to its formation, and its own prospects for future development.

The Murmansk Industrial-Transportation Centre, apart from the city of Murmansk itself, includes also the city of Kola and towns such as Murmashi, Shangui and Kil'dinstroi. The aggregate population is 336,000.* The base of its specialization is provided respectively by the fishing industry and sea transportation. The development of the main sectors of specialization gave rise to the formation of a system of support enterprises such as metal working (ship repairs), wood packaging, food production, electric power production, production of building materials, local agriculture, and a service sector. These sectors will also be considerably expanded in the future.

The share of the fishing industry is approximately 75% of the gross output and of the average number of workers in the centre.

From Murmansk, the largest seaport of the country,** are exported apatite, iron ore concentrate and other goods.

The growth and improvements in the structure of the fishing industry and also the increase in cargo handling by sea transportation facilities will remain in the future the principal directions for the development of the Murmansk industrial centre. These tasks can be met successfully if the fleet is augmented by new fishing and processing vessels and if there is an adequate level of development in ship-repair facilities. It will be essential to improve the assortment of fish products by increasing the volume of frozen and chilled fish, etc. A substantial amount of work should be done on the reconstruction and expansion of the Murmansk port and measures should be taken to synchronize the maritime and railroad transportation systems.

Especially significant will be the development of the service sector which will require an increase in the production of building materials and the expansion of the building industry. The capacity of the housing construction

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* Here and below, as of 15 January 1970.

** Sic - Murmansk is the largest arctic port in the U.S.S.R. and the only arctic port that is ice-free all year round. (Transl. Ed.)

combine will be increased in the next few years to 200,000 m^2 of residential housing per year. There is a plan for the construction of a new precast concrete plant, a shop for the production of partition materials made from gypsum, and a furniture factory. Bearing in mind that the available land on the right bank of the Kola Bay within the territory of the city are limited, the future growth of the industrial centre is possible through the development of the left bank of the Bay.

A substantial development will take place in the food industry as a result of the construction of a meat combine, bakery-confectionary combine, distillery for the production of liqueurs and vodka and a brewery, and the reconstruction of the dairy industry enterprise and of other existing enterprises of this sector of industry. A great deal of work must be done in the construction of residential housing and cultural and recreational facilities, as well as landscaping and tree planting, to create the most favourable living, recreation and working conditions.

The realization of all these measures will make it possible to improve the supply of goods to meet the needs of the population, and improve the cultural and living conditions. It will also improve the possibilities for the employment of women, and this will have a positive effect by reducing the mobility of the labour force.

<u>Khibiny industrial centre</u> includes the cities of Kirovsk and Apatity and towns such as Kukisvumchorr, Yuksporiok and Tik-Guba with a combined population of approximately 130,000. It has been formed and continues to grow on the basis of the Khibiny deposits of apatite-nepheline ores. Development is favoured also by the convenient transportation and geographical location near the Leningrad-Murmansk railroad and highway. The retarding factor in its development is the absence of a fuel and energy base of its own. However, with the commissioning of the Kola Atomic Power Station the problem will be resolved.

The formation of the Khibiny industrial centre was started in 1930 when the first mine began to operate extracting apatite-nepheline ores, and when a little later the first stage of the ore-dressing plant was put in

operation. At present the "Apatite" combine is the economic core of the industrial centre. It brings together several mines and two apatite-nepheline concentration plants producing more than 30% of the total phosphate materials in the country. In 1971, 11,800,000 tons of apatite and 1,200,000 tons of nepheline concentrate was produced. The mining-based chemical industry accounts for the main bulk of the gross output of the industry and of auxiliary facilities within the centre. The remaining portion of gross output falls into the category of support industries such as the Kirov Electric Power Station, a furniture factory, various workshops, a bakery and other enterprises.

The further development of the Khibiny centre will be primarily due to an increase in the production and extraction of more minerals from the apatite-nepheline ores. It is essential to insure an integrated utilization of the apatite and nepheline ores in order to increase the efficiency of production. The calculations of the Kola Branch of the Academy of Sciences of the U.S.S.R. have shown the economic advantages that can flow from obtaining not only apatite concentrates but also nepheline, titanite and titanmagnetite concentrates.

It would also be possible to build here a plant for the production of double superphosphate. However, the sulphuric acid which can be produced from the exhaust gases of the local copper-nickel plants would be sufficient for the production of only 700,000 tons of double superphosphate. If the capacity of the plant were to be increased substantially (1.5 - 2 times) it will become necessary to bring sulphur from other regions, which, according to calculations, is not fully justified from the economic point of view. The intended increase in the output of nepheline concentrate would, in the opinion of the authors, require the construction of a new nepheline plant within the centre. There is also a proposal for the construction of an ore-dressing plant in the region of the town of Apatity to process ore from the Keivskoe cyanite deposits which are to be brought into production.

The planned volume and scale of new construction would require a considerable expansion of the building industry base and an increase in the production of building materials, including those made from local raw materials, e.g. vermiculite, carbonates and others.

In connection with the rapid growth of the population of the centre, which doubled between 1959 and 1970, there should be a further increase in the support industries (meat-processing, dairy plant, and others), transportation, and the community service sector. This would also attract greater numbers of women into the labour force, who in the past have experienced some difficulties in obtaining employment because of the predominance of heavy industries).

The population of the centre is housed essentially in the two base towns of Kirovsk and Apatity. Climatic conditions in Kirovsk, which is located in the mountain valley of the Khibiny mountains, are more severe than in Apatity which has been built at the foothills of the Khibiny near the shores of Lake Imandra. The natural relief of Kirovsk makes building difficult and makes life less comfortable for the residents who are forced to move over rugged ground. It would therefore be advisable in the future to concentrate the main bulk of the population and consequently the residential and cultural and services construction in Apatity.

The main objective of combatting the unfavourable natural conditions in the industrial centre is the prevention of avalanches in Khibiny, where snow avalanches threaten the residential, industrial and transportation installations.

It is also essential to undertake measures for landscaping and tree-planting in the town of Apatity where, as far back as the thirties, the original forests were completely logged, and also to make better use of the recreational facilities of Lake Imandra. It is essential to strengthen measures to protect this main source of water for the Khibiny and Monchegorsk industrial centres from being polluted by industrial waste.

Petrozavodsk industrial centre is the main one in the Karelian A.S.S.R. It is located on the transportation lines linking it with the Northern and Central regions of the European part of the U.S.S.R. and the Baltic republics. It includes the city of Petrozavodsk and towns such as Solomennoe, Chalma, Shuya,

P'yazhieva, Sel'ga, with a combined population of over 200,000. The main industrial activities of the centre are machine building, metal-working, lumber production, wood-processing and a mica industry, accounting for two thirds of the gross output of the centre. There are also some enterprises related to the building materials industry, and to textile and food industries.

The favourable location from the point of view of transportation and geography, the availability of convenient sites for industrial and residential construction, adequate water resources, a large construction base and the presence of considerable reserves of nonmetallic mineral resources offer suitable opportunities for further development of the industrial centre. Within the next few years the construction of the V.I. Lenin "Tyazhbummash" (Paper Industry Heavy Machine Building Enterprise) will be completed. A machine tool plant, the Onega tractor plant, a branch of the Leningrad Plant "Svetlana", are to be expanded here. There is a proposal for the construction of a card-index equipment manufacturing plant, automated lines plant, and a wood-processing combine (in Chalma). The centre's specialization in machine building will be strengthened and its share in the overall industrial production will be substantially increased.

In order to improve the supply of consumer goods to the growing population it is proposed to locate here a number of new enterprises of the food industry (dairy products factory, brewery, confectionery factory, etc., and a garment-sewing shop and shoe factory.

There will be a substantial improvement in the fuel and power base of the industrial centre as a result of the construction of facilities such as the Petrozavodsk Thermal Power Station, a transmission line, and in the future, the possibility of bringing in natural gas from Leningrad. The shortage of manpower for the construction of enterprises which are to be built here could be partially compensated for by releasing people from the logging industry.

Because of the fact that Karelia has high-grade wood, and very clean water in Lake Onega, it is possible to consider organizing the production of high-quality pulp. But it is essential to undertake measures to improve

urban sewage collection and water purification equipment.

The natural conditions favour the expansion of agriculture on the peripheries of towns and health spas for the workers (organization of rest houses, sanatoria, and tourism).

In the future the importance of Petrozavodsk as an industrial centre will be increased while its leading role as an administrative and cultural centre of the Karelian A.S.S.R. will continue.

Arkhangel'sk Industrial and Transportation Centre includes Arkhangel'sk and Severodvinsk, as well as other towns such as Pervomaisk and Uima, with a total population of 525,000. Its development and production specialization has been determined first of all by the favourable transportation and geographical location where the North Dvina, a very important timber transportation artery of the European North, empties into the sea. At the same time it has direct railroad communication with the central regions of the country.

The centre specializes in logging, wood-processing, and pulp and paper industries. Arkhangel'sk is the most important centre in the country for the integrated processing of wood and is a port for forest products through which approximately 30% of the lumber exported from the U.S.S.R. passes.

Machine building also plays an important role in the industrial structure of the centre, including ship-repair yards (Krasnaya Kuznitsa, and others), and the production of machinery and equipment for the forest industry (Solombal'skii machine-building plant, and others).

The growing requirements of major construction and the availability within the region of various raw materials (clay, gypsum, lime, wood) have favoured a relatively large development of the building materials industry.

The food industry is represented mainly by fish-processing and the light industry by stockings and socks and footwear manufacturing.

An important task, both for the present and for the future, is to increase chemical and mechanical processing of wood with a view to its fuller and more integrated utilization. Production of wood-based board and wood flour has been organized in recent years. The utilization of rejects and trimmings from lumber production as inputs for pulp and paper and hydrolysis enterprises will in the future be increased even further. According to calculations, as a result of the fuller utilization of rejects from logging and wood-processing in pulp production and in the production of wood-based board, up to 2,000,000 m^3 of industrial wood can be saved in the Arkhangel'sk industrial centre. Within the next few years the expansion and reconstruction of the following lumber and wood-processing combines will be completed: No. 2, 3, V.I. Lenin Kegostrovskii plants, Solombal'skii paper and wood-processing combine, Arkhangel'sk Pulp and Paper Combine, and others. Work has been started on the construction of a pulp mill and of a furniture factory. The completion of the Arkhangel'sk - Karpogory - Yavzory - Mezen railroad will make it possible to expand the raw material supply for the wood-processing enterprises of the Arkhangel'sk industrial centre by bringing under exploitation the forests in the basins of the Mezen, Pinega and Vashka rivers.

The fuel and power base of the centre will be considerably improved when Ukhta and Tyumen gas is brought in through the Kotlas - Arkhangel'sk pipeline.

As a result of the planned construction of a plant for overhauling construction and road-building machinery, and also as a result of the expansion and reconstruction of the "Krasnaya Kuznitsa" ship-repair yard, the importance of machine building and metal working will be enhanced still further in the structure of the centre. There are favourable conditions for developing a chemical industry, specifically for building a plant to manufacture chemical products for consumer needs and a plant for the production of plastics using rejects from wood-processing and pulp and paper enterprises, and also using natural gas brought in from other regions.

It is proposed that the fish catches should be increased still further, also the gathering of marine algae. This will necessitate expansion of the Arkhangel'sk fish combine and the factory processing algae. A considerable

growth in population (between 1959 and 1970 it increased nearly 140%) makes it necessary to build new enterprises for the food industry (confectionery factory, bakery combine, brewery, dairy, etc.), for light industry (garment manufacturing factory, reconstruction and expansion of the shoe factory, etc.) and the development of all forms of transport (marine, river, railroad, road, and air).

The expected expansion of the Arkhangel'sk seaport will make it possible to handle the growing volume of exports and of commodities intended to supply the needs of the Far North and High Arctic regions. Interregional transportation links of the centre will be considerably improved as a result of the construction of the Arkhangel'sk - Vologda - Yaroslavl highway.

In accordance with the proposed plans for the development of Arkhangel'sk and Murmansk there should be a considerable growth in the service sector, and in the construction of residential, communal, service and cultural facilities. These will require the stengthening of the construction base (building of plants for the production of concrete, reinforced concrete components, keramzite, etc.).

The current urgent task of the centre is to intensify local agricultural production, specifically to expand the present greenhouse units and build new ones, using heat from the Arkhangel'sk thermal power station, heat waste from the forest industry enterprises, and gas heaters. Especially favourable conditions for the development of market gardening exist in the valley of the North Dvina River, along which the products can be conveniently brought to Arkhangel'sk. The implementation of large-scale drainage operations would also aid in strengthening the agricultural base of the centre, particularly at Severodvinsk.

Kotlas Industrial Centre includes the town of Kotlas and smaller towns such as Koryazhma, Vychegodskii, Privedino, Cheremushskii and Shipitsino (with a total population of 111,200). It has been formed on the basis of forest resources of the adjoining territories, using its convenient transportation and geographical location at the junction of the North Dvina and the Vychegda rivers and at the intersection of highways and railroads. Kotlas is an important

trans-shipment point where processing and trans-shipment of cargoes from water to rail, and vice versa, takes place.

Logging, pulp and paper, and wood-processing industries occupy the main position in the industrial structure of the centre. Their share in the gross industrial output amounts to 70%. Substantial forest reserves in the vicinity of the centre make further expansion of this sector both possible and economically justifiable. With the commissioning of the second stage of the Kotlas Pulp and Paper Combine its capacity will increase more than 150%. The raw material base of the combine can also be expanded through a more thorough use of rejects (amounting to more than 200,000 m^3 annually) from the wood-processing enterprises located in the centre. Machine building is of considerable importance. This is represented by the Limendskii ship-building and repairing yard and various repair workshops which serve the logging industry and transportation.

The integrated formation of the economy of the Kotlas industrial centre has been favoured by the development of the building materials industry and the construction industry ("Kotlasbumstroi" trust) [Construction trust for building the Kotlas Pulp and Paper Combine], electric power engineering (thermal power station of the Kotlas Pulp and Paper Combine) and the food industry. Within the construction base there are plants for the production of reinforced concrete components, ready-mix concrete, standard housing construction, wood-finishing combine and a mechanical repair shop. There are also several brick factories.

The availability of sufficient reserves of wood, water, a relatively large construction base, convenient sites for buildings, expansion of the fuel and power base (the gas pipeline "Siyanie Severa" [Northern Lights]) favour further development of the centre essentially along the line of increasing the capacity of the Kotlas Pulp and Paper Combine (the construction of the third stage) and development of the machine-building industry. There are proposals for the construction of a plant to produce plumbing equipment for repairing pulpwood-handling equipment, for manufacturing electrical engineering products, etc.

At the same time an expansion of service sectors will take place. It is proposed to build a plant to produce silicate brick, a plant for bottling grape wines, and an expansion of the thermal power station of the Kotlas Pulp and Paper Combine.

The Plesetsk Industrial Centre, an industrial centre of national importance, has developed on the basis of the rich North Onega bauxite deposits. It includes Plesetsk, and towns such as Savinskii, Puksozero, Oksovskii and Emtsa, with a combined population of approximately 38,000. In future it is proposed to build a new large town of Severo-Onezhsk.

A large bauxite mine is now under construction, and in future it will be the location of an aluminum oxide plant, an electrocorundum plant, and an oil refinery. The fuel and power base of the centre will be considerably expanded as a result of bringing oil and gas through branch lines from the proposed Kotlas - Arkhangel'sk gas pipeline and Ukhta - Yaroslavl oil pipeline.

The other important sector is the building materials industry represented by the Savinskii cement works which make use of the very rich deposits of lime available here.

The convenient transport and geographical location, the presence of a good supply of water, and of free areas for construction sites favour the development of the Plesetsk industrial centre into an important industrial complex of nonferrous metallurgy, oil refining, building materials production, and other sectors. The development of these industrial sectors and the proposed development of natural resources will require an expansion of the transportation network, industrial support sector (power, food industry, and others) and service sector. Considerable residential housing and community service construction, and the creation of an agricultural zone of appropriate size will be required.

The Syktyvkar Industrial Centre has a favourable economic and geographical location, being situated on the Vychegda River and on the railroad branch line of the Northern railroad. It includes Syktyvkar and towns such as Ezhva, Krasnozatonskii, and others, with a combined population of 140,000.

The future development of this industrial centre is primarily linked with the development of the wood-processing and pulp and paper industry utilizing the forest resources (amounting to over 600,000,000 m^3) in the basins of the Vychegda and Sysola rivers.

Within the immediate plan period the construction of the Syktyvkar forest industry complex (FIC) will be completed. According to the plan, the annual production will be: 600,000 tons of paper, 345,000 tons of pulp, 248,000 tons of cardboard, over 116,000 tons of veneer, 280,000 m^3 of lumber, 100,000 m^3 of wood-chipboard, and other products. In terms of the volume of wood processed (4,500,000 m^3 annually) the Syktyvkar FIC will become one of the largest in the European part of the U.S.S.R. approaching the output of the Bratsk FIC, the largest in the country. It is also expected that the lumber-milling and wood-processing combine and the furniture factory will be reconstructed.

The construction of the second and third stages of the Syktyvkar FIC, which will include enterprises essentially using rejects from logging and wood processing, will guarantee fuller and more integrated use of the wood logged in the region.

It is proposed that in the region of Syktyvkar a large chemical complex be set up. This would include the production of titanium dioxide using local salt from the Seregovskii deposit. But this will require further study.

Construction and building material industries will be further developed. A large-scale development of the production of wall materials is backed by the availability of local mineral raw materials (clay and sand). Bearing in mind that in the region of Syktyvkar high cost factors are fewer than in the northern regions of Komi A.S.S.R. (specifically there are no northern increments to the basic pay), it would be advisable to create a base for the construction industry and to organize production of building materials that would meet demands originating not only in the Syktyvkar industrial centre but also in a number of other industrial centres and points in Komi A.S.S.R.

An important problem is to increase the machine building which up to now has been represented by small mechanical shops and several repair shops. In the opinion of the authors it will be necessary to rebuild these enterprises and to build new ones, such as a plant for the repair of building and road machinery, a plant to produce steel structural components for the building industry, etc. It is also proposed to locate here branches of Leningrad centralized overhauling shops to service electrical engineering equipment, electrical measuring instruments, etc.

The increase in the population of the centre, and the need to satisfy its requirements more effectively, makes it necessary to develop the food industry further (confectionery plant, dairy, brewery, and others), and light industry (a textile factory), as well as the service sector.

The construction of the Syktyvkar FIC and of other large enterprises will require improving the transportation network and a considerable expansion of the electric power base. At present, Komi A.S.S.R. is supplied with power by isolated power centres (Syktyvkar, Ukhta, Vorkuta) and by individual power stations. In the next few years these should be unified and included in the general power system of the Northwestern Economic Region. The fuel supply of the centre has been considerably reinforced as a result of bringing in natural gas through the Mikun - Syktyvkar branch pipeline from the main "Northern Lights" pipeline.

The construction of two sections of railroads (Ertom - Karpogory and Syktyvkar - Peles) will be of considerable importance for the industrial centre. As a result of this Syktyvkar will be linked directly with Arkhangel'sk and with the regions of the Volga Basin and the Urals.

Realization of all these proposals will further increase the importance of Syktyvkar as an important industrial and major administrative and cultural centre of Komi A.S.S.R.

<u>The Vorkuta Industrial Centre</u> includes Vorkuta and towns such as Oktyabr'skii, Severnyi, Tsementnozavodskii, Komsomol'skii, Vorga-Shor, Promyshlennyi,

Khal'mer-Yu, Khanovei, Mul'da, Yun'-Yaga, and others, with a combined population of 200,000. Its origin and growth are based on the development of coal deposits in the Pechora Basin. The coal industry accounts for approximately 80% of the gross output of the centre.

The future expansion of the Vorkuta industrial centre will depend mainly on the completion of the Vorga-Shor mine No. 1, and the reconstruction of existing ones. This will make it possible to increase the output of coking coal from 12,700,000 tons in 1970 to 18,000,000 tons in the future, and if necessary to 26,000,000 - 28,000,000 tons. The construction of large, highly mechanized mines based on the Vorga-Shor and Usa deposits will ensure a substantial increase in the techno-economic indexes of the coal industry. Another important task facing this industry is to raise the quality of coal by means of more intensive cleaning. The implementation of the task will be greatly aided through the construction of a large central cleaning plant.

It is essential to increase the use of Pechora coking coal for coking (at present only 60% is used for coking). This can be done if the coal is sent not only to the Cherepovets plant, but also to plants in the Centre,* and in future to the metallurgical plant which can be built using the iron ores of the Kursk magnetic anomaly.

Future development of the Vorkuta industrial centre and improvement in the living conditions of its population will be determined by the expansion of support industries. An increase in the volume of building materials is favoured by the availability of local raw materials (lime, marl, sand, gravel, etc.) and industrial wastes from the coal mines and thermal power stations.

At the same time it would be economically justifiable to supply many materials, prefabricated components and parts from regions located further south, where their production is not encumbered by the high-cost factors prevalent in the North. Even after taking into consideration transport costs they would prove to be cheaper in the Vorkuta economic region than when produced locally.

* The main industrial regions of the European U.S.S.R. (Transl. Ed.)

In future there should be a considerable expansion of electric power production (expansion of the existing thermal power stations and possibly also transmission of electricity from the Pechora state regional power station and from other power stations in the Komi A.S.S.R.) and the mechanical repair base (reconstruction of the Vorkuta Mechanical Plant and of other enterprises). An important issue for the centre will be the reduction of skilled labour mobility and integration of greater numbers of women into the labour force. This will be fostered by improved living conditions, maximum servicing of the towns with electricity, heating and gas utilities, the establishment of textile and shoe factories, and also food industries to meet the needs of the population with respect to perishable and difficult-to-transport food commodities. There will be a need to expand dairies and bakeries, construct a refrigeration plant, a garment manufacturing factory, and also establish, in the vicinity of Vorkuta, dairy farms, poultry farms, greenhouse combines, etc.

The role of Vorkuta as a cultural centre of the Soviet High Arctic will increase.

In the future there will be a considerable expansion in the Ukhta Industrial Complex. It has been developing on the basis of the oil and gas production industry of the Timan-Pechora province which is endowed with an exceptionally favourable combination of diverse natural resources, accessible for a large-scale industrial exploitation. At present it includes the towns of Ukhta, Sosnogorsk and smaller towns such as Yarega, Vodnyi, Voi-Vozh, Nizhnyaya Omra, Nizhnii Odes, Vuktyl, with a combined population of over 110,000.

The production of oil has increased considerably as a result of the exploitation of the West Tebuk deposits, and that of gas through the opening of the very large Vuktyl deposits. In the next few years it is essential to develop other promising oil deposits (Usinskoe, Syninskoe, Savinoborskoe, Michayusskoe, and others) and gas deposits (Rossokhinskoe, Kur'inskoe, Pechorgorodskoe, Pechorokozhvinskoe, and others) and also to organize a fuller and more efficient utilization of casing-head gas and gas condensate. In addition to increasing oil refining at the Ukhta plant, a portion of the oil produced will be transported by pipeline to Yaroslavl and Plesetsk.

An urgent problem is to increase exploration work in the Timan-Pechora province for oil, gas and other natural resources. It is essential to determine with greater precision the size of oil and gas deposits of the Kolvinskii arch and the Khoreiveiskaya depression which adjoins it, where many promising sites have been identified. This will be in accordance with the tasks set by the Directives of the XXIV Congress of the C.P.S.U. for the new five-year plan, which expresses the need to intensify the discovery and development of the new deposits of oil and natural gas in the regions of the European North.

The availability of rich deposits of titanium, bauxites, and limestone, as well as fuel, water, and convenient construction sites in the central regions of Komi A.S.S.R. creates favourable conditions for the development of nonferrous metallurgy on the scale of national importance and of a chemical industry (e.g., production of pigment titanium dioxide). The concentration of extensive reserves of high-quality mineral raw materials, the rising needs for building materials, and the favourable transportation and geographical location of the complex, favour the formation of a large industrial centre for the production of building materials, and of a construction industry. In particular, it would be advisable to build plants to produce cement, prefabricated large panels for housing construction, precast concrete, and lime for the building industry.

To realize all these measures it will be necessary to increase the electric power supply and repair services, to increase further the production of certain consumer goods, to expand the service sector, as well as to develop local agriculture and improve transportation (especially pipeline). In the long run it would appear to be reasonable to extend the Sosnogorsk - Troitsko-Pechorsk railroad as far as Solikamsk, which would improve the links between the territory discussed and the Urals (deliveries of coal, timber, oil products, etc.).

Thus, on the basis of the extensive natural resources in the central and northwestern parts of Komi A.S.S.R., a large Timan-Pechora territorial industrial complex will develop, which will be of great importance to the country in the production and processing of oil, natural gas, titanium and bauxites ores and moreover, to the economy of Komi A.S.S.R. in the production and processing of

mineral building materials and forest products. The Ukhta industrial centre will develop as the main component of this complex.

This analysis of the main industrial centres of the European North makes it possible to draw the following conclusions.

The majority of the industrial centres of the European North are being formed on the basis of the development of natural resources, and the expansion and reconstruction of existing enterprises. But the exchange of goods and services between the individual enterprises and centres has been insufficient. The possibilities for combining engineering services, joint use of repair and storage facilities, transport, and water supplies, are not fully utilized. Shortcomings in the structure of industrial centres are: poor development of repair facilities, construction enterprises, production technology that would make integrated use of raw materials and rejects from the food and other light industries, insufficient growth of establishments providing public services and recreation, etc.

At the same time in some of the industrial centres of the European North (Vorkuta, Khibiny and others) a certain degree of lateral integration can be noted. This can be seen from the increase in population even though there is an insignificant development in sectors of specialization. The population grows as a result of poor mechanization of the main production processes and the use of equipment which is not adapted to northern conditions, and also because of the considerable growth of various support industries. In some industrial centres an unfavourable sex and age structure of the population has evolved as a result of the predominance of production technology, which uses primarily male labour.

In conclusion, it is essential to stress that the most important condition for the correct, harmonious development of the territorial production complexes and for preventing the shortcomings pointed out above is the timely preparation and implementation of regional planning.

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BASIC PROBLEMS IN THE DEVELOPMENT OF THE TIMAN-PECHORA ECONOMIC COMPLEX

The Timan-Pechora province holds one of the largest reserves of oil and gas. The potential reserves of oil are estimated at billions of tons, and natural gas at trillions of cubic meters. Already over 30 deposits of oil, natural gas, oil and gas, and gas condensate have been discovered. Among these are numerous large and super-large deposits (Usinskoe oil deposits, Vuktylskoe and Laya-Vozhskoe gas deposits, Vasilkovskoe oil and gas, and others), which offer a higher production efficiency than medium size deposits.

The territory of the Timan-Pechora industrial complex which is being formed here, and which embraces the northern and western parts of Komi A.S.S.R., as well as Nenetskii National Okrug of the Arkhangel'sk Oblast has been prospected and assessed only in part, and new large deposits may yet be discovered. However, the estimated resources and geological forecasts show that it will be desirable to form in the region a very large fuel and power base for the European part of the country.

Its important advantage lies in the fact that in relation to the fuel-deficient regions of the Centre, the Northwest, and the Baltic area, the Timan-Pechora complex lies only half as far as the Northern Ob region, and only one third as far as the oil industry complex of Western Siberia. This results in a time gain and in an economy of material resources.

In spite of the high cost factors of the North, geological explorations have insured a high rate of growth in the production of oil and natural

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Problemy Severa, (18): 131-140, 1973.

gas, and, based on this, an increase in the efficiency of capital investments in the oil and gas industry. During 1966 - 1970, in terms of the cost of developing the reserves ready for exploitation (0.38 rubles per ton of conventional fuel), Komi A.S.S.R. was second to the northern regions of Tyumen Oblast. In 1970, so far as the main economic and technical indexes are concerned (wellhead costs, capital intensity, labour productivity), the oil producing industry of Komi A.S.S.R. has come very close to the average for the country as a whole[1].

In addition to oil and natural gas the Timan-Pechora complex has large reserves of coal for power and coking. The geological reserves of coal in the Pechora Basin are 214 billion tons, confirmed commercial reserves of categories A + B + C amount to 8.3 billion tons, of which coking coals amount to 3 billion tons. The low sulphur content and the virtual absence of phosphorus makes it possible to produce a high quality coke from Pechora coals. In relation to the principal metallurgical centres of the European Centre, the region is located at about the same distance as Donbass, and is less than half as far as Kuzbass.

Apart from the fuel resources, the region has extensive deposits of mineral raw materials, among which are the unique Yarega deposits of titanium ores, which have a high content of titanium dioxide. These reserves would make it possible to attain a very large volume of extraction. According to calculated data the unit capital investments in the production of Yarega titanium concentrate are half as high as in other similar enterprises.

The Timan region is one of the most promising for bauxite production. In terms of volume and the quality of raw material already explored bauxite deposits are not inferior to those in the northern Onega region. According to preliminary data, the deposits in the Sredniy Timan which are being currently studied have bauxites of a higher quality and can be worked under more favourable conditions.

The presence in the Ukhta region of huge deposits of limestone (Bel'gopskoe deposits) in combination with rich fuel resources creates favourable conditions for large-scale alumina production in the region. At the same time the Bel'gopskoe deposits of high quality limestone and clays located in the vicinity of the town of Ukhta is of considerable importance for the development of a building

materials industry in the region.

Together with mineral resources the territory of the complex is richly endowed with forests and fish, the latter including such valuable species as Atlantic salmon, whitefish, grayling, and taimen. It has considerable resources of surface and ground water, adequate to meet the needs of the population and also for the development of industries with large water requirements.

The Timan-Pechora complex occupies two of the most severe natural climatic zones of Komi A.S.S.R., the central and the northern, and it also includes the Nenetskii National Okrug. Most of this territory has a climate with a prolonged and relatively cold winter, and short and relatively warm summer. The natural fertility of agricultural lands is low, with podzol soils changing in the north into tundra type.

The large territory occupied by the complex has been, as yet, little developed industrially. In 1970 it was inhabited by 590,000 people, living primarily in towns and work camps (75%). From among the six towns the most developed industrially are Ukhta and Vorkuta. The high proportion of the population of working age and a natural increase in population in general favours the formation of labour resources.

According to approximate calculations, in 1970 industrial enterprises produced 900,000,000 rubles worth of goods, while the value of their capital equipment was estimated at 1 billion rubles. Approximately 60% of industrial output came from the fuel industry: oil production and refining, natural gas, and coal. Machine building and metal working are represented in the region by relatively small mechanical repair enterprises. There are also wood processing and building materials industries. The food and textile and leather industries are of purely local importance and their raw material base is very limited.

Agriculture is a subsidiary activity specializing in dairy and beef cattle breeding, production of potatoes and vegetables. There has been some development in poultry breeding on an industrial basis, as well as pig

raising, and in the northern regions, reindeer breeding. Of principal importance are sovkhozes and subsidiary agricultural enterprises attached to industrial plants. In 1970 they accounted for over 80% of the production of milk, 90% of meat, and nearly all eggs. In the region of Vorkuta and Inta alone there are eleven large agricultural enterprises (subsidiary units), among which are eight specializing in dairy products and milk, one in reindeer breeding, and one in growing vegetables in greenhouses. There are also greenhouses in a number of other towns and camps using waste heat from industrial plants.

Plans for the future of the region call for a considerable development of the oil and gas industries by the exploitation of the large deposits located in the northern portion of the complex's territory. Already during the present five-year plan there will be a substantial increase in oil production and collection of casing head gas. Work is being completed on the installation of field facilities at the Michayusskoe and Savinoborskoe oil deposits where production will soon begin. At the Yarega deposits secondary recovery of heavy oil has begun using the method of thermal stimulation of the pay zone. The coefficient of oil recovery will reach 50% of the residual reserves, while the unit consumption of steam per ton of extra oil obtained will be 2.5 - 3 tons.

The gigantic reserves of the Vuktyl gas condensate deposits will make it possible to raise the production of natural gas in the near future to 20 billion m^3. Special attention is being given to the condensate, each ton of which is equivalent to two tons of crude in the production of light oil products.

In the more distant future oil production may reach 40 - 50 million tons, and gas, 50 - 80 billion m^3.

It is proposed to increase oil and gas processing even further. The capacity of the Ukhta Oil Refining Plant will be increased by 150%. Carbon black production in the gas-processing plant will be expanded further. A more complete collection of casing head gas at oilfields will permit, within the current five-year plan, an increase of 190% in its utilization. By using casing head gas it will be possible to establish a natural gasoline production plant with an output

of ethane, propane, butane, and natural gasoline, as well as dry benzine-free and liquified gas.

Project calculations have shown that it will be economical to develop a petrochemical industry with facilities for the production of acetylene and ammonia (using the exhaust gases from pyrolysis and low pressure natural gas), channel or electrotechnical black from acetylene, as well as ammonium nitrate, and other products. When it will be economically justified, production of polymer goods will also begin, specifically polyethylene pipes for water systems and for the needs of the oil and gas industries, as well as plastics for use in the building industry.

Coal production will increase from 22 million tons (1971) to approximately 28 - 30 million tons. The further increase in the production of coking coal is justified by the national situation with respect to coking and chemical raw materials and the location of a new metallurgical plant within the territory of the Central region. It is expected that the Vorga-Shor deposits will be developed further and the development of the Usinskoe deposit will be started.

It is essential to increase geological prospecting substantially, first of all by means of deep exploratory drilling in the most promising regions. Explorations have already started in the territory extending from the upper reaches of the Pechora River to the Arctic Ocean. A basic increase in oil and gas reserves is expected to come from the highly promising areas in the north, while that of coal would be from the Pechora coal basin. Expansion of geological prospecting will insure an optimum build-up of explored reserves for new mines to satisfy the future demand for Pechora coal.

The long-range plan provides for the development of the titanium and bauxite reserves. It is proposed to build a mining and dressing combine at the Yarega deposits which will deliver raw materials to the pigment titanium dioxide plant to be built in Komi A.S.S.R. There is also a proposal to develop alumina production making use of deposits which have more favourable conditions for their development (the possibility of using open-cast mining, favourable

hydrogeological conditions, absence of sulphur in the raw materials, etc).

There will be a fundamental change in the structure of the forest industry. There will be an improvement in raw material utilization through mechanical and chemical processing of wood, maximum possible use of rejects, low-grade wood, and broadleaf species. New forms of wood processing will develop, including production of plywood, particle and fibre boards.

As a result of reconstruction and new construction of enterprises for repairing mining machinery, automobiles, building industry machinery and equipment there will be an increase in repair and mechanical workshop facilities. Production will become specialized and will be technically re-equipped and strengthened.

The fast rate of the proposed industrial development will require a considerable expansion of the electric power base. During the current five-year plan the construction of the Pechora State Regional Power Station (GRES) is due to be started. At present the existing thermal power and heating stations are being expanded and new ones are planned. The unification of the isolated electric power regions (Vorkuta, Inta, Pechora, Ukhta) into a single power grid is becoming of utmost importance. The power resources of the region make it possible to develop large-scale production of electric energy, not only for local needs, but also for delivery to power-deficient regions of the Centre and the Northwest.

The development of the new oil and gas deposits and the solution of the problem of integrated development of the region's economy, which includes wide-scale residential and cultural housing construction, will require a substantial increase in the production of building materials and the strengthening of the construction industry base of the region. There will be a sharp increase in plant capacities for the production of wall and structural materials. Industrial plant building, incorporating prefabricated reinforced concrete components, will be widely used. Standardization of components will be carried to the maximum.

House-building combines, now operative in Ukhta and Vorkuta, will be reconstructed. They are being adapted to produce residential housing suited for northern conditions. New house-building combines with a production capacity of 100,000 - 120,000 m^2 of living space are to be built in Ukhta and Pechora. In addition, in Pechora a house-building combine is planned for the production of room modules, which will favour the introduction of house building using the module assembly method. This will result in a substantial reduction in the transportation of building industry cargoes.

Even within the next few years Ukhta will become an important centre for the production of building materials - cementing materials, pre-fabricated reinforced concrete components, wall panels, light aggregate, etc.

The availability of many natural raw materials and of industrial wastes (slags, ash) is a necessary condition for an accelerated development of the production of efficient and economic building materials, in particular, light concrete.

For the time being the existing transportation network in the territory of the complex does not meet the needs of the national economy. The problems of providing transport facilities in northern territories far removed from railroad have not yet been solved.

It will be necessary to create a well developed network of pipe-lines with an appropriate system of compressor stations, and to build the necessary highways, and later, probably also railroads.

The extensive, highly promising in terms of oil and gas, territories of the northern part of Komi A.S.S.R. and Nenetskii National Okrug have no permanent roads, and contact with prospecting and exploration teams is maintained by helicopters, by rivers in summer and by winter roads in winter. The development of the northern zone of the Timan-Pechora province should be based on a permanent road network. It would appear that the first priority should be given to the construction of a railroad to the bauxite deposits. At the same time it would provide access to extensive forest stands, and the good

construction materials of Timan.

Particular attention must be given to increasing the through-put and transport capacity of the existing railroad, river, highway and air transportation facilities, and to all-round mechanization of loading and unloading operations. A study should be made on the advisability of building the Solikamsk - Ukhta - Indiga railroad with an outlet to the Barents Sea. This would provide a route for the export of oil products, coal, forest products, and Solikamsk potash fertilizers.

Further development will take place in the Vorkuta and Ukhta industrial centres, and the formation of the new Pechora centre will be speeded up. Ukhta, Pechora and subsequently Nar'yan-Mar can be regarded as base towns for opening the northern regions.

Within the Ukhta industrial centre (an industrial and transportation centre for oil and gas production) an increase in the volume of oil and gas processing is taking place. In the next few years it is planned to produce natural gasoline, and in the more distant future, possibly other petrochemical products. Electric power generation will be further developed, the repair base will be enlarged and there will be an increase in the production of building materials and consumer goods. The service sector to the population will be expanded.

In the Vorkuta industrial centre, after the mine at the Vorga-Shor deposits has been put into operation and the intensive cleaning of coal initiated, the complexity of the coal industry will be further increased.

The Pechora industrial centre is to become the economic centre for the development of the Bol'shezemel'skii oil-bearing region. With the completion of the Pechora State Regional Electric Power Station it will also become an important centre of power production.

In the southern part of the Timan-Pechora complex, N. Odes and Voi-Vozh could grow to become towns, and in the northern part, the settlement of

Usinsk, followed by other settlements, will probably join the rank of towns. This will make it possible to organize cultural and consumer service facilities, and increase the standard of housing and transportation. This will favour the formation of a permanent labour force and a settled population.

The development and modernization of the social infrastructure has become the basis for the formation of the economic and social structure of every territorial production complex.

It is obvious that in the severe natural climatic conditions of the Far North special attention should be given to improving the living conditions of the population. The long-range norms provide for an increase in the total area of apartments compared with the central regions of the country, and also more spacious storage and service rooms. Residential buildings will have forced-air ventilation with preheating of the incoming air. In a number of cases preference will be given to the construction of town complexes to include under one roof residential units, kindergartens, schools, trading outlets, gymnasiums, and winter gardens.

The new and significant stage in the development of the Timan-Pechora complex, involving the exploitation of large new additional fuel resources and raw materials of mineral and plant origin, focuses attention on the urgent problem of protecting the environment and making rational use of renewable and nonrenewable resources. It is essential to improve the protection of the animal and plant kingdoms and to safeguard the air, and water basins.

Academician N.N. Nekrasov stressed that "Under present conditions one cannot consider the use of various types of natural resources without taking into account the consequences to the environment, and measures for the protection of the natural resources"[2].

Rational limits for the extraction of natural resources, and the possibilities for their renewal, should be forecasted. There should be a decisive stand against irrational depletion of resources and violation of the environment.

In the North, more than anywhere else, the attitude of people to nature should be based on the principle of minimum disturbance of natural conditions resulting from man's economic activity. Nature in the North is sensitive to any form of interference.

The development of methods for the rational use of nature's resources and of strict measures for the protection of the environment are becoming even more important in the North than in the middle latitudes.

One of the first priorities is to limit the impact of industrial wastes on the environment. Up to the present time the most acceptable approach has been treatment of wastes, and setting of pollution norms. Furthermore, it is necessary to start with the assumption that the unfavourable impact of effluence and industrial wastes upon the environment can, to a considerable degree, be eliminated. Through correct planning of waste disposal, intensified measures of treatment and economic use of wastes, it is possible to preserve the riches of nature without slowing down the rate of industrial development.

Norms should be worked out for the permissible effect of harmful substances on man, and quantitive evaluations of noxious discharges which can be considered acceptable. The presence of harmful contaminants in the air or water should not exceed the levels at which damage could be done to the health of people or cause irreversible changes in the environment.

Much has been done in this direction already. In Vorkuta the following steps to reduce atmospheric pollution have been taken: 27 small boilers have been shut down, cyclone ash separators have been installed on ten boilers, preparations are being made to switch a number of boilers to burn casing-head gas. At Inta the "Kapital'naya" mine, with its own resources, built settling ponds which made possible the reduction of the amount of suspended particles in the mine discharge by 90%, and measures are being taken to reclaim and replant the territory.

At the Inta ore-dressing plant the slurry waters are purified and used repreatedly in a closed production cycle. The release of discharge waters

has been completely eliminated. The same solution has been introduced at the thermal electric power centre in Inta.

At the "Zapadnaya" and "No. 17" mines of the "Intaugol" (Inta coal) and "Vorkutaugol" (Vorkuta coal) combines the mine discharge is purified to the level of drinking water and then used to supply water to the cleaning plant, boilers, for irrigation, as well as for dust control in the mine.

At the Tebukskoe oil and gas and Voi-Vozh oil field administrations incentives are consistently used to encourage workers and employees to use water efficiently and to purify it. This is one of the reasons why all of the produced water, after appropriate treatment, is injected into the pay zones or into absorbing horizons.

The personnel of the Yarega Oil and Mining Administration has had some positive results in discharge treatment. The content of hydrocarbons in the discharge has been reduced to a fraction of what it used to be.

Bringing the quality of mine water to the required levels of purity costs only 5 - 6 kopeks per m^3, while the cost of water from the Inta water supply system, for example, is 14.6 kopeks, and in Vorkuta it is 24 kopeks. The treatment of mine discharge results in a substantial economy of resources.

But in a number of cases the measures introduced have not been adequate, because they were not integrated.

In the town of Sosnogorsk a special zone is to be set aside for production activity which can result in health hazards. It is located to the north of the town, down wind from the residential area, below the water intakes from all the rivers, outside the water catchment area of the surface and ground waters used by the residential area, and situated at high points which insure good airing of the sites where noxious and explosive substances may be discharged into the atmosphere. It would appear advisable to concentrate the new oil and gas enterprises, the building materials production and petrochemical plants in this zone.

To the south of Ukhta and Sosnogorsk it is proposed to create a forest park zone for recreation and to reserve some territory for housing, and for industrial constructions for enterprises that will pose no health hazards.

There must be no delay in carrying out measures to reduce the amount of pollutants discharged into the air and water from the existing oil and gas processing plants. Support should be given to a proposal made by a number of scientists that the amount of maximum permissible levels of pollutant discharge should be set not just for one single industrial plant but for the entire town and for the whole industrial region. This would encourage industry not only to reduce the pollution of the environment but it would also force it to develop new production technology, that would make use of wastes, improve methods of gas and water discharge treatment, make the industry switch to closed cycles and recycling systems in the use of water and air. This would result in restoring the environment, and in many instances in the saving of valuable products.

Special attention should be given to agricultural land. In the regions of Vorkuta, Inta, Pechora, Vuktyl, and Usinsk, the agricultural base has been formed under difficult northern conditions, requiring large additional expenditures of labour and funds. For the future development of local agriculture it is necessary to regulate the use of agricultural land, to introduce reclamation work, provide the necessary equipment for farms, and ensure scientifically sound application of fertilizers. It is necessary also to raise the level of intensification in northern reindeer breeding by means of selective breeding and efficient use of pastures.

It can also be expected that some benefits may be derived from the intensification of sowing pastures and tree planting where the tundra conditions are most favourable.

In the more southern parts of the Timan-Pechora complex the possibilities for organizing agricultural production are of course greater. Large-scale

work to improve the stock feed base is being done, for example, by the state farm of the "Komineft" consortium. During the eighth five-year plan the production of succulent fodder has increased by 30%. The formation of a reliable fodder base has resulted in high productivity. In 1971 the yield was 3,935 kg of milk per feed cow.

In the development of industrial production there is an urgent need for greater responsibility in the strict adherence to the legal requirements of agricultural land protection, and the efficient use of every hectare of land.

Better use should also be made of land set aside for urban construction. For this it is necessary to increase the density and height of buildings. With five-storey buildings, for example, the density of housing in Vorkuta amounts to 4,000 - 4,500 m^2 per ha. Changing over to high-rise buildings would decrease unit capital costs, increase convenience and reduce the length of service lines.

In the course of developing northern regions it is essential also to keep in mind the rules for the efficient use of the tundra. It is known that frozen ground is not stable, and that disturbance of the protective vegetation cover may result in thawing and deformation. Industrial dumping which disturbs the surface of the tundra in the vicinity of mines may also prove to be harmful. It is essential to work out special methods for seeding vegetation of these dumps. It is also necessary to develop modes of transportation that would not be destructive to the thin vegetation cover over the permafrost.

The maximum preservation of the environment (air, water, soil, and vegetation), when new towns and industrial and agricultural enterprises are being built, should become the norm in setting efficient principles of town building in the Far North.

One of the basic natural resources is water, especially pure, fresh water. The Timan-Pechora complex has many bodies of water in its territory. Apart from the Pechora, which is one of the largest rivers of the European North, there are many small rivers, streams, and lakes. This favours the development

of industrial production. The production and processing of oil, coal, and gas, the proposed production of alumina, wood-based boards, and many other products, require large expenditures of water.

The source of water for the oil and gas industry is primarily surface water. The water supply must be sufficient to flood the wells, and to provide water for technological processes, and drinking water for the population. For this it will be necessary to build a number of new water intake points, purification installations, facilities for injecting water into oil formations, and water ducts. The use of water will increase during the next decade alone by 250 - 300%. At the same time a considerable increase in the volume of produced and polluted water can also be expected. The most rational solution would be to pump it back into the formations. The water can be recycled without thorough treatment to reduce the amount of fresh water for flooding purposes.

The Pechora River and its main tributaries, being of great importance for fisheries, require special attention. Fish catches in the Pechora Basin can be considerably increased. It is necessary to improve the organization of fishing and fish management, to solve the problem of rearing fish to marketable size, stocking and acclimatization of fish, to make use of the possibilities of increasing the productivity of lakes, including lakes situated in the High Arctic. It is important to protect the rivers from pollution.

It must be borne in mind that under the conditions prevailing in the North the process of self-purification of rivers occurs very slowly on account of the low temperatures. Whereas in the middle latitudes river waters completely free themselves of pollutants after approximately several tens of kilometers from population centres, in the North the distance has to be considerably greater. Consequently more efficient protection and purification systems are necessary.

In the towns of Ukhta, Pechora, Inta and Vorkuta construction has begun of large water treatment stations, which are designed to remove all pollutants from effluence. These stations are being provided with equipment to ensure the best available technology, and will be able to yield pure water, corresponding to drinking water in quality. It is essential that their construction be

accelerated, and their stock of funds, personnel, equipment and the necessary materials should be improved.

Wider use should also be made of underground water sources. In Ukhta, reserves of high-quality water have been found in ancient Carboniferous and Devonian formations. In Pechora, water was found in alluvial deposits, and in Vorkuta and Inta water can be drawn from fissures in bedrock. Underground water is better protected from surface contamination. In terms of quality and taste as a rule it is not inferior to river water, and the presence of a number of chemical components with medicinal properties makes it capable of stimulating heart activity, and improving body metabolism.

Forest resources, one of the most important endowments of the area, also require careful consideration. Group I forests and the nonviable reserves should be considered separately. These are essentially forests which form the pretundra protection zone, the water protection areas and protective belts along the navigable rivers, railroads and highways, around towns and campsites. Logging in them is not permitted, since otherwise it would be impossible to prevent the advance of the tundra and increase in the northern, hurricane-type winds. Logging out of these forests would result in the drying up of streams, dropping of the water level of rivers, and would have a harmful effect on the health of town dwellers, who need fresh air.

A serious danger that threatens the forestry economy is the decline in the value of the taiga forests. It is essential to prevent the wholesale change from conifer to broadleaf species.

According to data from the Laboratory of Silviculture and Forest Management of the Komi Branch, Academy of Sciences, U.S.S.R., in pine and spruce forests with maximum retention of the young trees it is possible to reforest successfully. In order to ensure the desired composition of future stands, selective cutting and clearing should be done in the young conifer-broadleaf forests. Natural regeneration should be facilitated in combination with planting and sowing of trees.

Of great importance are forest reclamation operations. Drainage of forest lands greatly improves the productivity of timber stands, increases the rate of growth, and provides favourable conditions for logging and reforestation.

The interests of the good forest management demand a more rational utilization of forests and of lands belonging to the State Forest Resources.

Taiga forests are rich in fur-bearing animals, Siberian pine nuts, berries, mushrooms, and in fodder, medicinal and technical plants. It is necessary to improve the management of harvesting these riches.

Natural forests located in the vicinity of towns such as Ukhta, Sosnogorsk, Pechora, and Inta require special care. This would make the rest and recreation time of the citizens more rewarding. Clearing operations in green belts and parks can be entrusted to enterprises and organizations to which individual sectors of the forest are assigned, and where they have their recreation facilities.

Good management requires population counts and knowledge of the principal fur-bearing and game species of animals, the planning of seasons and quotas for fur-bearing animals and game to be shot, and constant care for restoring the populations of taiga wildlife. In this connection, special significance has to be given to expanding game management and biotechnical measures in the forest, such as setting up supplementary feeding areas, installation and maintenance of gravel beds and salt licks, and organization of effective protection of animals and birds from poachers. It is essential to regulate the harvesting of waterfowl, and to protect their nesting and wintering grounds. Rare and vanishing species should be treated with special care.

Hunters too need some assistance. Up to the present time in Komi A.S.S.R. full use is not made of those funds allocated for the study and development of new rich hunting grounds, for the construction of huts and houses for hunters, storerooms and cold storage. Not enough is being done to take the hunters and supplies to hunting grounds, and to take out the pelts and game.

Increasing the efficiency of utilizing natural resources is of great national significance even at the present rate of production.

In recent years losses have been reduced at the mines in Inta and Vorkuta. Water injection and thermal stimulation enhance the recovery of oil. There has also been an increase in the utilization of casing-head gas and condensate.

Improving the equipment and technology used in producing and processing raw materials will make it possible to increase considerably the efficiency of investments in primary industries, and to make the greatest and most integrated use of every ton of crude oil, condensate, coal, and every cubic meter of gas, obtained from the ground.

In the forest-surplus regions of the complex's territory the wood-processing industry is poorly developed, and there is practically no chemical processing. It is sufficient to say that in the Troitsko-Pechorsk region, one of the more promising in Komi A.S.S.R., only 9% of the logged timber was sent for processing (1972). And yet in the region there are favourable conditions for the wide-scale development of various forms of wood-processing, possibly also for the production of pulp and paper products. In such a case, however, it will be necessary to provide for the appropriate treatment of discharge water before any pulp and paper production could begin.

The intensification of the use of natural resources and measures for their protection should be closely related. Rational use of the natural resources of the European North will ensure increased efficiency in the development of the Timan-Pechora economic complex.

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DEVELOPMENT OF RESOURCES IN NEW NORTHERN DEVELOPMENT REGIONS AND THE PROBLEM OF PROTECTING THE NATURAL ENVIRONMENT

Experience gained in the U.S.S.R. in the industrial development of new regions, including those located in places with difficult climatic conditions, has made it possible to work out a scientific approach to development and to establish guidelines for the preservation and improvement of the environment. As an example, one may take the West Siberian Plain, a large region of new industrial development. Based on very rich resources of oil, natural gas and forests, a large economic complex of national importance is being formed at the present time, including the largest base for oil and gas production in the country. As is known West-Siberian gas will become the cheapest fuel for most regions in the U.S.S.R. The total volume of oil and gas production, which will be sent from the northern reaches of the Ob to the European part of the U.S.S.R., the Urals, and industrial centres of Siberia will, in the next 15 - 20 years, reach over 1 billion tons in terms of conventional fuel. This region will become in the future the main base for supplying fuel and power to the national economy. Oil and gas will permit a fundamental change in the fuel balance of the country. A proportion of gas and oil obtained will go for export.

The forest-rich zone of the Near North of Western Siberia has extensive reserves of valuable wood, cheap fuel, water resources, and convenient sites for locating logging, wood-processing, and pulp and paper industries. Furthermore, it is located at a relatively short distance from the main consumers. This will create favourable conditions for the development in this region of large chemical and mechanical wood processing centres of national importance. It is proposed to build several forest industry complexes which will process more than 20,000,000 m^3 of wood per year.

Problemy Severa, (18): 141-146, 1973.

Along with the growth of capacities in the main producing industries, there has been a rapid growth in electric power capacities, construction, and production of building materials. In connection with the rapid capital growth in the region the establishment of a social and production infrastructure has become an urgent necessity. It is well known that a well organized, developed infrastructure ensures increased efficiency in industrial activity. This is one of the basic methods of increasing efficiency in bringing rich natural resources into production in the regions that are being newly developed.

The presence in the North of large resources of hydrocarbon raw materials, combined with almost unlimited cheap fuel and power and water resources, the availability of good sites for locating enterprises, and adequate means of transportation, provide favourable conditions for the formation of petrochemical complexes in the southern part of the West Siberian Plain. The construction and commissioning of the Tobol'sk and Tomsk oil refining complexes will lay the foundations for the establishment of a very large petrochemical industry in the eastern part of the country. In the future a large base can be created here for the production of mineral fertilizers, which will be capable of meeting the needs of agriculture in Western Siberia and the trans-Ural area. All the necessary conditions for the creation of such a base are met.

During the last few years the Council for the Study of Resources, Gosplan, U.S.S.R., together with scientific research and planning organizations of the Academy of Sciences, U.S.S.R., and various ministries and agencies, has carried out scientific research on the development of new territories and the formation of territorial production complexes in such new territories. Schedules are being prepared for the integrated development of the economy of new territories endowed with a high concentration of natural resources, and ways are being studied for the most efficient, integrated development of these natural resources.

In these studies a great deal of attention is being devoted to the northern regions.

Both Soviet and foreign (primarily Canadian) experience in developing resources in new regions indicates that before attempting to exploit the resources

available in such regions, and before forming territorial production complexes it is necessary to make a thorough scientific, technical and economic study. In every case such work must precede industrial development. It includes a study of natural conditions and the determination of estimated reserves of mineral and other resources; it also provides for a thorough assessment of forest resources. A study is made of hydro and energy resources, directions of their possible utilization are determined, and conditions for the development of agriculture are studied.

In making scientific, technical and economic studies for the development of new territories, it is necessary to prepare large-scale topographical, hydrogeological and soil maps, as well as maps showing marshes, permafrost, locations of peat resources, mineral resources, and the preparation of integrated atlases of the region. Such thorough mapping of the territory makes it possible, even during the first years, to avoid errors in achieving the full potential in developing the economy of the region. It makes it possible to mark out, with a greater degree of accuracy, the location of the new industrial centres, towns, workers' settlements, and individual industrial enterprises. The main directions of railroads and highways, electric transmission lines, and oil and gas pipelines can be identified.

One of the conditions for the efficient development of new regions is the study of climatic and hydrogeological conditions and determining the main directions for reshaping nature. In the course of this, special attention should be given to environmental and climatic regionalization involving: the study of surface and ground-water resources, forecasts of changes in natural conditions, thorough study of permafrost conditions, investigating the drainage possibilities of marshy lands, and irrigation of dry regions, study of ways to create the most favourable living and working conditions for the population (insect control, preparation of scientifically backed recommendations for the construction of buildings and installations suitably adapted to local conditions, etc.), and study the pattern of terrain dynamics.

The advance study of problems connected with the reshaping of nature is particularly important when opening up territories in the North. As has been

learned from experience in developing resources of the West Siberian Plain, insufficient knowledge of all the special features of the territory can affect the rate of development of the economy as well as the technical and economic indexes of producing oil and natural gas, and round logs.

An important condition for efficient development of new territories is the preparation of schedules for the integrated use of forest, peat, fish, and fur resources.

In preparing long-term plans for the integrated use of the forest resources of the West Siberian Plain, Giprolesprom (State Institute for Designing Enterprises for Wood-Processing Industries), Giprobum (State Institute for Designing Enterprises for the Pulp, Paper and Hydrolysis Industries) and Giprolestrans (State Institute for Designing Enterprises for Logging, Wood-Drifting, Wood-Processing and Wood-Transportation enterprises) and other institutes have defined not only the volume of wood to be taken out and processed, but also the main directives for reforestation. Such governmental approach to the problem of bringing forest resources into exploitation is the most rational.

While preparing the long-range plan for the development of the fishing industry, Giprorybproekt (State Institute for Designing Enterprises for the Fishing Industry), and SibNIIRKh (Siberian Scientific Research Institute of the Fishing Industry) have conclusively shown that it is possible to increase fish catches considerably my making proper use of fish resources, organizing wide ranging efforts in fish breeding, carrying out a number of improvement measures, establishing lake fisheries, extending fishing operations to taiga and tundra lakes, and protecting bodies of waters from being polluted with industrial wastes and cluttered with debris as a result of wood drifting, etc. These recommendations by the scientific research institutes have been accepted by administrative organizations and, as a rule, are implemented.

One of the principal measures of economic preparation in developing northern territories is to lay down a scientifically substantiated basis for the development of agriculture, taking into account natural and climatic conditions.

Analysis of the events which occurred in the creation of the territorial production complexes in Irkutsk Oblast and Krasnoyarsk Krai have shown that during the first stage of their formation not enough attention was devoted to the development of agriculture. This complicated the normal and timely supply of food products to the population, and resulted in additional expenditures involved in bringing such products from other regions (for example, from Central Asia).

As a result in planning the potential development of resources in new regions in the West Siberian Plain the most economic alternatives for supplying food products to the newly forming centres were determined in advance. The rapid growth of specialization sectors of the complex, and the population increase associated with it, made it necessary to speed up the rate of developing the local agricultural production base. Within the development regions over 30 specialized sovkhozes were formed which were oriented towards the production of meat, milk, and vegetables. Poultry farms and greenhouse units are being organized. Already in 1970 more than 450 tons of potatoes were produced in the regions, nearly 400 tons of vegetables, nearly 4,000 tons of milk, considerable amounts of meat, eggs and other agricultural products. An increase in the output of agricultural products can be realized in future by including more of the flood-plain meadows of the Middle Ob and of its tributaries, but even more so by increasing the yields of farmlands and the productivity of animal husbandry. Large agricultural complexes will be organized here, and these will be capable of meeting the basic needs of the population for agricultural products. In the course of this all the components of development, such as the growth in population, natural and climatic conditions, agricultural resources, present level of agricultural technology and the special nature of agriculture in northern regions and the adjoining territories, should be considered.

The concluding stage of the scientific and technical groundwork for developing new territories should be the preparation of a scientifically justified long-term schedule for the integrated development and allocation of resources in the region. This would take into account the following factors: the economic evaluation of the natural resources of the region to be developed; the effect

these resources could have on the rate of economic development of the resources of the country as a whole; the economic effect which would result from bringing under exploitation the forest, peat, oil, gas and other resources of the territory; the nature of specialization of the territorial production complex; the development of transport facilities within the region; the composition (structure) and preliminary scales of the territorial production complex; the capital investments required to open up the new territories and to develop the main production sectors of the complex; and also those necessary for the formation of an industrial and social infrastructure demanded by the work and life activities of the population. Account should be taken of labour requirements by all the sectors of the complex, and how this labour force can be induced to remain within the region. Attention should be focused on the biggest projects planned for construction at the outset, the formation stages of industrial centres, and the intra- and interregional links to be developed by the complex.

When the development of resources within the territory of the West Siberian Plain was started, the natural environment was practically untouched. The huge scale and rapid rate of development of the main economic sectors, and the heavy equipment used in developing oil and gas deposits and other resources, have effected a rapid change in natural conditions.

In the course of opening up the new territory a large number of oil and gas fields have been established, dozens of exploratory and production wells have been drilled, a network of local pipelines, compressor stations, central collection points for gas and oil, access roads, and roads between fields have been built. The territory has acquired a network of oil and gas main lines, highways, railroads, towns, industrial buildings and other installations. All this has had a certain effect upon the natural environment of the region.

The development of the oil and gas industry has been accompanied by logging out of extensive forest areas, and by disturbance of hydrological, hydrogeological and permafrost regimes. It has been accompanied by changes in relief, soils, vegetation cover, and microclimate of the territory on which new construction has taken place. In the course of this both desirable and harmful changes

in the natural conditions of the region have occurred.

At present, while the amount of wood taken out within the territory of the West Siberian Plain has not exceeded 20 - 22 million m^3, up to 140,000 ha of forest area is being logged out annually. In future, according to calculations made by the author, the areas logged out will reach 280,000 - 300,000 ha. The forest industry will have an increasingly greater effect on the natural environment of the region. Consequently, along with logging, measures should be undertaken immediately to ensure reforestation of the areas logged out.

Within the territory of the West Siberian Plain, especially in the Tomsk Oblast, there are tracts of Siberian pine forests, whose area is in excess of 3,000,000 ha. These are particularly valuable. In Tomsk, Kozhevnikovo, Shegarka, and other regions of the Oblast, the pure stands of Siberian pine growing around human settlements cover considerable areas. These are Siberian pine forest parks which for decades have been protected by the population. Evidently the first Siberian settlers extended every care over the Siberian pine stands.

The care taken to protect Siberian pine stands is a matter of great national importance. In 1966, the Council of Ministers of the R.S.F.S.R. passed a resolution "On improving the management of Siberian pine forests". In 1968, a scientific conference dealing with problems of development and allocation of resources in Tomsk Oblast had placed on record in its resolutions that it is essential to organize special Siberian pine management units. At present, plans have been completed for such a management unit in the forests of the Lower Keta hunting and trapping range.

But there are times when recommendations are not acted upon. In Tomsk Oblast the annual logging of Siberian pine still amounts to approximately 20% of the total volume of logging. During the past 10 - 15 years the areas covered with Siberian pine forests have shrunk considerably. And it must be noted that the Siberian pine logs are used as building material, and pit props.

The development of resources in new regions in the West Siberia Plain has shown that the initial period of development of natural resources has not resulted in an appreciable deterioration of the natural environment. During 1966 - 1970 in the Yamalo-Nenetskii National Okrug, in spite of the wide-scale geological prospecting and other operations, there has been an increase in the number of reindeer. Reindeer breeding is expanding, and specialized units are being formed in this field.

The wide-scale use of biological resources is closely linked with the implementation of measures for the protection of natural conditions in the taiga and tundra. The nature and the degree of utilization and protection of these resources is determined in many respects by the overall process of developing the West Siberian Plain. In particular, the use of modern machinery and equipment and of modern means of transportation, combined with a rapid growth of population, can result in undesirable effects on the plant and animal world. In the tundra of Yamal and Gydan great harm to the vegetation cover is being caused by heavy tractors and all-purpose vehicles. Their movement in the summer is already subject to regulations confining them to definite routes, since otherwise serious damage is likely to be done to reindeer pastures, and erosion processes will be started.

In the taiga zone, especially in the south, irrational, and sometimes indiscriminate logging often takes place. Frequently forest stands by rivers are logged out, and so on. Many rivers are cluttered with dead wood. Because of this careless attitude there are frequent forest fires in the taiga. Large tracts of forests burn out, resulting in losses of hunting, berry, and mushroom resources, and large areas of lichen pastures are destroyed.

Special attention should be given to the protection of the northernmost forests and the sparse forest stands fringing the tundra. According to preliminary calculations made by the Institute of Geography, Academy of Sciences, U.S.S.R., in the Taz Basin the continued use of the resources is economically much more justifiable than a one-time removal of a small amount of wood from these forests.

In order to protect the biological resources, and ecological systems as a whole, and to bring them under rational exploitation, it is necessary to work out a scientifically substantiated system of special measures. One such measure should be to allocate land tracts strictly to enterprises that would keep a profit and loss account, and a broad system of controls should be instituted so that these land resources are put to proper use. This would increase the extent to which enterprises would show concern for the rational utilization and conservation of useful animals and plants. At present a large proportion of hunting and fishing land resources, reindeer pastures, forest stands and other taiga and tundra areas are allocated to the users.

It is essential to continue the development of various modes of biological resource management that correspond with socialist principles. It is necessary to assist in the formation of new enterprises and expand the state and cooperative economic units that make use of biological resources in the taiga and tundra. The organization of new integrated sport, tourist, hunting, and fishing enterprises and bases should occupy an important position. The network of all the production and sport enterprises should be developed on a basis of cooperation between various administrative organizations. This should be done in accordance with a plan that would take into account the local natural and economic conditions.

It is very important to organize zakazniki where the animal world is protected. Particularly common in Western Siberia are fish zakazniki. To give a specific example, at present fishing is forbidden in the majority of large sors of the Upper Ob Basin (Shurykarskii Sor, Pitlyarskii Sor, and others).

It is essential to organize game zakazniki in the areas where there are large concentration of wild reindeer, and particularly in areas where game birds gather. In particular, a network of zakazniki should be set up for the protection of waterfowl in the flood plane of the Ob, in the places of mass migration, nesting sites, and molting areas. Hunting should be outlawed on larger sors. This can be done very easily, since most of them are restricted areas so far as fishing is concerned. As a result, sors will become valuable integrated zakazniki for commercial fish, and game. The organization of zakazniki to protect the rapidly vanishing capercailzie should be considered as one of the more urgent

measures. The zakazniki should be located in places where there is a mass concentration of birds in the fall and along river banks, where they go to pick grit.

Zakazniki should be organized in all places where game is threatened with extinction (for capercailzie, for example, on the Ob and on some of the other accessible tributaries: the Kyunovat, Polui, Konda, etc.) and not in the middle of inaccessible taiga. It is also necessary to create zapovedniki, which do not yet exist in Western Siberia. First of all the Konda-Sos'va zapovednik, which was terminated in 1951, should be re-established. It provided protection for the unique population of Siberian beavers and is a representative sample of the middle-taiga forest of the Ob-Ural region. New zapovedniki should be created in all the natural zones of Western Siberia where intense economic development of the natural resources is taking place.

Recreation zones should be created in the regions of large industrial development, in the vicinity of new towns and settlements. The health and aesthetic aspect of forest use could be combined in these zones with the collection of berries, mushrooms, Siberian pine nuts, fishing and hunting. It is essential to carry out integrated studies of local ecological systems and of their biological resources. On the basis of such data an overall schedule could be compiled. This should embody the use of natural resources of the region and envisage large-scale planning for those regions which are to be developed first. Such regions are: Vasyugan'e, Middle Ob Basin, Lower Irtysh Basin, Lower Ob Basin, Konda Basin, the area of the Ivdel - Ob railroad line, Tyumen - Tobol'sk - Nizhnevartovsk railroad line, Asino - Belyi Yar railroad line, and others.

Resolutions on the protection of the environment published in the present collection of papers are mandatory so far as the preparation of future plans for the development of resources is concerned, and require that special attention be paid to measures for the protection of the environment. The plans should provide for: economically justified allocation of land for industrial, residential, road and other construction, integrated utilization of natural

resources, implementation of integrated environment protection measures so far as the replenishment of biological resources is concerned. The plan should provide for measures aimed at protecting water, atmosphere, land, forests, fish and game resources. This is fully applicable to an area of new development, such as the West Siberian Plain.

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REGIONAL SPECIALIZATION IN MACHINERY PRODUCTION FOR THE NORTH

The organization of serial production of special machinery and equipment for northern use is one of the most important tasks facing the machine-building industry of the U.S.S.R.

An important problem in determining the methods of organizing and locating machinery and equipment production for northern regions is to assess the need for such machinery and equipment. The basis for such an assessment should be a regional classification of the U.S.S.R. according to climatic conditions that would meet the technical aims and operating conditions for the equipment and machinery.

According to operating conditions machinery, equipment and instruments which are sent to northern regions can be divided into three groups: 1) machinery and equipment to be operated in open-air conditions, 2) machinery and equipment to be used in heated premises, 3) machinery and equipment for premises which are not to be heated. Such a grouping makes it possible to set out the directions for organizing the technical methods of production for northern conditions.

Machinery and equipment of the first and second groups represent the general demand that must become the basis for plans for the development and location of specialized machine-building capacities intended to produce machinery and equipment for northern conditions. Machinery and equipment of the third group are produced in series and are used regardless of the climatic conditions of the region.*

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* It would seem that groups 2 and 3 are in the wrong order. (Transl. Ed.)

Problemy Severa, (18): 147-153, 1973.

Machinery and equipment of the first and second groups should be subdivided into special equipment for northern conditions, and standard equipment modified for use in the North.

A basic requirement for determining the economically justified demand for machinery, equipment and instruments of each particular category should be information of a sufficiently reliable nature relating to the technical rationale and the economic advantages which would result from their use in the expansion of production, and as replacement for machinery and equipment previously used.

For practical determination of the future needs of various sectors of the national economy in the northern zone for machine-building industry products a system of amalgamated normative indexes should be developed which would show the demand for the respective types of machinery and equipment per unit of work done by sectors that use such equipment, and the production plans of each user should be established according to the plan periods. They should be prepared for the zone as a whole and for its individual regions.

These amalgamated normative indexes should reflect the average demand for machinery, equipment and instruments per production unit that is the most characteristic for a given sector, and used in planning, taking into account the natural climatic, geological and other conditions of the northern zone.

The absolute value of these consolidated norms showing demand according to groups of machines and equipment must not be assumed to be constant over time and space. As the range of the machinery and equipment produced for northern conditions increases and the ratio between specialized equipment and modified standard equipment changes, and also as a result of the influence of a number of other factors, these norms may change for respective periods of planning.

The total demand for machinery, equipment and instruments for the northern zone should in the long term be assessed in terms of a number of alternative formulations. These demand alternatives can be determined by the rate of development of various sectors in the northern zone as a whole, or of individual sectors as they figure in the national economy of the country.

To provide a rationale for the most effective location of production of regional machinery and equipment, especially for the extensive territory of the North, it is essential to know the demand for such equipment by individual regions.

The demand of each individual region for a given type of machinery and equipment can be expressed using the formula

$$\Pi_j^{ks} = \sum_{p=1}^{P} A_{pj}\alpha_p^{ks}, \qquad (1)$$

where:

p - number of the economic sector of the northern zone (p = 1, 2, ..., P);

j - number of the regions of the northern zone (j = 1, 2, ..., m);

k - number of the type of machine-building output (k = 1, 2, ..., K);

s - number of the machine-building sector, producing the k-th type of product (s = 1, 2, ..., S);

Π_j^{ks} - aggregate demand on the j-th region for k-th type of output of the s-th sector of the machine-building industry;

A_{pj} - volume of gross output or type of work of the p-th sector of the national economy, designated for production in the j-th region of the North during the period under consideration;

α_p^{ks} - amalgamated norm of the consumption of the k-th type of output of the s-th sector of the machine-building industry to produce one unit of gross output or type of work in the p-th sector of the national economy of the northern zone.

The overall demand of the northern zone for the k-th type of product from the s-th sector of the machine building industry (Π^{ks}) is determined as a sum of demands of the individual regions.

$$\Pi^{ks} = \sum_{j=1}^{m} \Pi_j^{ks} = \sum_{p=1}^{P}\sum_{j=1}^{m} A_{pj}\alpha_p^{ks}. \qquad (2)$$

Then the overall demand for various types of machinery and equipment of each individual sector of the machine-building industry should, as has already been stated, be aggregated into groups which would take into account the conditions under which they are to be used. This should be done by regions and for the zone as a whole.

Group I - standard machinery and equipment;

Group II - northern modifications of the standard equipment and machinery;

Group III - special equipment and machinery for the northern zone.

The demand of the northern zone and of its regions for machinery and equipment, subdivided into the proposed groups, would make it possible to deal with the problems of organizing the production of the given type of product of the machine-building industry, and also would indicate how such production should be specialized and how it should be centralized. How the production will be organized, and how much it will be centralized will depend upon solutions of the problems indicated above.

The development of specialized production of northern machinery and equipment must be considered methodologically as an integral part of the development of the whole machine-building industry in the country. The special features of this production will make it possible to single it out into an independent sector at a specific stage of planning.

The wide range of northern machinery and equipment which we intend to produce and the considerable demand for it in the future, make it economically essential to specialize in their production; furthermore this specialization should be done in various forms (by commodity, by component, and from the technological point of view) in both the sectoral and intersectoral aspects. This is required by the complexity and diversity of technological processes of producing northern versions of machinery and equipment.

The level of development of specialization in production in terms of commodities, components, and technology differs for different groups of machinery

and equipment produced for northern conditions. The use of standard equipment in the northern regions has practically no effect on the specialization of the basic stages of its production. But in the packaging of the finished products machine-building enterprises should form specialized sections so that packaging would conform with the technical requirements of transporting the finished product to the northern buyer.

In the production of the northern modifications of standard machinery, equipment, and instruments the most promising appears to be specialization in production of components and technological specialization. The use of additional fittings, special designs of individual components and mechanisms or parts to be made of special cold-resistant materials in most cases necessitates no further differentiation of the mechanical assembly production lines of the final product. As a rule, the assembly of northern modifications should be done in machine-building plants, in shops that produce the same type of machinery in its standard form, using the same assembly lines and the same equipment. However, depending on the special design and technological features of various components and mechanisms produced as northern modifications of standard machinery and equipment, the standard technological processes and assembly lines should be supplemented with specialized sections or equipment depending on the technology of their production. In individual cases, when there is a considerable demand for northern modifications of standard machinery and equipment, which exceeds the annual production capacity of a plant manufacturing them, it would be advisable to consider whether it might not be better to have separate mechanical assembly plants, workshops or sections specialize fully in the production of such machinery and equipment. This direction in the development of mechanical assembly is most characteristic for vehicle and earth-moving construction, and mining machinery production. The intensification in specialization within a mechanical assembly plant would make possible a maximum concentration of the additional operations and stages of production of this machinery and equipment; it would also allow the introduction of special equipment and instruments, and also make it possible to train the labour force in the special nature of operations performed.

The development of specialization in the production of components (castings, forgings, and welded components), parts, units, and mechanisms for

northern modifications of standard machinery and equipment is not always the same, and depends upon a number of factors.

The use of special materials in casting in some cases requires specialization in the methods of casting. Frequently, casting into ordinary sand or liquid self-hardening forms is replaced by casting under pressure or by the use of moulds. This makes far more compact and durable castings, which ensure the reliability of the designed product under northern conditions. Intensification of specialization of semifinished component production within the limits of an individual machine-building enterprise producing standard machinery and equipment and its northern modifications is in most cases economically not justified.

Bearing in mind the overall direction in the development of specialized semifinished component production in the machine-building sectors, and the increased production of northern modifications of standard machinery and equipment, intensification should be considered as part of the general system of establishing sectoral and intersectoral specialized component-producing enterprises. With such an approach to the organization of component production it becomes possible to improve specialization in the alloying of metals, allocation of contracts, method of fabrication, and other characteristics and parameters.

The most rational direction for the development of specialized production of components, parts and mechanisms used in manufacturing northern versions of standard machinery and equipment should be determined with consideration of the overall needs of machine-building sectors producing standard machinery and equipment. Specialized machinery and equipment for the North, depending on the overall demand within this zone, should be produced by independent plants, workshops and sections. Standard parts, components, and mechanisms can be more economically supplied by cooperation with the appropriate specialized sectoral and intersectoral production enterprises. The production of special, nonstandardized parts, components and mechanisms can be organized both within the framework of the mechanical assembly enterprises themselves, and in separate specialized workshops and sections set aside for nonstandard production within the system of the given sector, machine-building complex, or centre.

The economic rationale of specialization in production with respect to all the basic changes in the technological process of manufacturing machinery and equipment is closely linked with the need to determine the optimum level of production concentration. The intensification of specialization in production favours an increase in concentration which in turn creates favourable conditions for further growth in specialization. However, this growth depends on the range of the products manufactured, diversity in types and sizes, level of development of machinery, equipment and technology, and the planned volume of production of each model, type and size of product by the end of the period of planning under consideration.

Intensification of specialization by commodity in the production of machinery and equipment for the North makes it possible to exclude it from the structural subdivisions of machine-building plants producing standardized machinery and equipment and also creates conditions for concentrating production at an increasingly smaller number of enterprises. On the other hand, excessive plant and interplant specialization in the production of machinery and equipment for the northern regions would probably result in a decline in the size of production runs, which could become a retarding factor in the introduction of high-productivity modern equipment, and in the use of the best technological processes and forms of industrial organization.

The best direction for the development of all the forms of specialization and the level of concentration in the production of northern versions of machinery and equipment should, in our opinion, be determined by the minimum total efficiency-adjusted costs, bearing in mind the overall demand for them in the national economy of the northern regions by the end of the plan period under consideration.

$$З^k_{np} = \sum_{f=1}^{F} \sum_{s=1}^{S} (C_f^{ks} + E_н K_f^{ks}) X_f^k \qquad (3)$$

on condition that $\sum_{f=1}^{F} X_f^{ks} = П^{ks}$,

where:

f - variant of specialization of the k-th type of output in the s-th sector of machine building;

$З^{k}_{np}$ - aggregate efficiency-adjusted costs of production of the k-th type of output in machine building, taking into account the overall volume of demand for it in the northern zone;

C^{ks}_{f} - cost of producing one unit of k-th type of output in the s-th sector of machine building assuming the f-th variant of production specialization;

E_{H} - normative efficiency coefficient of capital investments in the production of the k-th type of output in machine building;

K^{ks}_{f} - unit capital investments in the production of k-th type of production of the s-th sector of machine building assuming the f-th variant of specialization;

X^{ks}_{f} - volume of production of the k-th type of product in the s-th sector of industry, assuming the f-th variant of specialization.

Having examined all the possible variants of specialization in the production of the k-th type of output in one or several s-x sectors of machine building, using formula (3) we find the lowest sum of operating costs and capital expenditures which are essential to produce the required volume of the appropriate product.

Different variants of specialization in the production of the k-th type of output in machine building, assuming clearly defined demand for it in the national economy of the North, will result in different levels of its concentration. Consequently, the unit cost of production and the unit capital investments must be inserted in formula (3), depending on the annual capacity of production.

The theoretical unit cost of production and the unit capital investments change with the change in the volume of production in accordance with the

hyperbolic law, which can be expressed using the following formula*:

$$Y = \frac{C_1}{X + C_2} + C_3,$$

where:

Y - unit cost of production or the unit capital investments per unit of output;

X - scale of output of product;

C_1, C_2, C_3 - coefficients characteristic of certain types of products and specific conditions of production.

The coefficients C_1, C_2, C_3 can be expressed by fixed volumes of output (X_1, X_2, X_3) and the corresponding costs of production (or the unit capital investments) per unit of production (Y_1, Y_2, Y_3) using the following formulae:

$$C_1 = \frac{(Y_1 - Y_3)(X_1 + C_2)(X_3 + C_2)}{(X_3 - X_1)}; \quad C_2 = \frac{\frac{Y_1 - Y_3}{Y_2 - Y_3} X_1 - \frac{X_3 - X_1}{X_3 - X_2} X_2}{\frac{Y_1 - Y_3}{Y_2 - Y_3} - \frac{X_3 - X_1}{X_3 - X_2}};$$

$$C_3 = Y_1 - \frac{C_1}{X_1 + C_2}.$$

Using these formulae for every variant of specialization in the production of the k-th type of output in machine building for the northern zone it is possible to obtain a concrete mathematical relationship between the unit production cost or the unit capital investments on the one hand, and the level of concentration in production on the other.

In order to obtain the specific mathematical relationships which correspond best of all to the hyperbolical law, it is essential that the coefficients C_1, C_2, C_3 be determined assuming three different levels of output with the same production technology structure.

The relationship between the unit cost of production and the annual

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* Yu. K. Kozlov. Organizatsionnye problemy nauchno-tekhnicheskogo progressa (Organizational problems of technological progress). Moscow, izd-vo "Mysl", 1972.

volume of production of machinery and equipment in their northern version can be seen from the following table.

Product	Annual volume of northern modifications of machinery and equipment	Percent of northern modifications in the total standard production	Cost increase factor per unit of northern modification as compared with standard production
One-bucket excavator	150	5.3	1.25
Hammer pile driver	26	2.2	1.49
Cranes mounted on pneumatic tires	8	1.0	1.52

From the data given above it can be seen that single-unit production even of northern modifications of standard machinery and equipment costs considerably more than production in larger series. When producing specialized machinery and equipment for northern areas the effect of the scale of production on the unit cost of production and unit capital investments is even greater.

Thus, analyzing, with the help of formula (3), the possible variants of specialization and the levels of production concentration we can identify the most competitive variants of organizing the production of northern machinery and equipment from the point of view of the lowest current and nonrecurring production costs.

To choose the most efficient variant for the location of production, the efficiency-adjusted costs obtained for all the competitive variants of specialization must be refined still further taking into account the differences in natural and economic conditions of the region's location and the cost of delivering finished products to consumers. In calculating the economic advantages of the k-th type of output, the regional differences in natural and economic conditions where production is to be located become apparent from the unit cost of production and the unit capital investments. Various payments for labour, heat, electric power, raw materials and other inputs, construction and assembly work, building

materials and equipment, result in different unit costs of production and capital investments in different economic regions.

The total efficiency-adjusted costs, taking into account various current and nonrecurring expenditures according to the regions where the machinery and equipment for northern regions is produced, and the transport costs involved in delivering the finished products to the users can be expressed in the following form:

$$3^{k}_{np} = \sum_{i=1}^{n} \sum_{f=1}^{m} \sum_{s=1}^{S} [C^{ks}_{fi}(X^{ks}_{fi}) + E_{н} K^{ks}_{fi}(X^{ks}_{fi})]\, X^{ks}_{fi} + \sum_{i=1}^{n} \sum_{j=1}^{m} a^{k}_{ij} X^{k}_{ij}, \qquad (4)$$

where:

i - the number of the region where the production is to be located ($i = 1, 2, \ldots, n$);

X^{ks}_{fi} - annual volume of production at an i-th point of location of production of the k-th type of output of the s-th sector of machine building, assuming the f-th variant of specialization;

$C^{ks}_{fi}(X^{ks}_{fi})$ - unit cost of production of the k-th type of output in the s-th sector of machine building, taking into account the natural and economic conditions of the i-th region of location, assuming the f-th variant of specialization and a scale of output equal to X^{ks}_{fi};

E_H - normative coefficient of efficiency of capital investments;

$K^{ks}_{fi}(X^{ks}_{fi})$ - unit capital investments in the production of the k-th type of output of the s-th sector of machine building bearing in mind the natural and economic conditions of the i-th region of location assuming an f-th variant of location and the annual scale of output equal to X^{ks}_{fi};

d_{ij}^{k} - efficiency-adjusted transportation expenditures for the delivery of the k-th type of finished product from the i-th region of production to the j-th region of consumption;

X_{ij}^{k} - volume of transportation of the k-th type of product from the i-th region of production to the j-th region of consumption.

The lowest total efficiency adjusted costs of producing the k-th type of output in regions i-x and the expenditures for delivering it from the place of production to the place of consumption, assuming the maintenance of a balance between production and consumption

$$\sum_{i=1}^{n} \sum_{f=1}^{F} \sum_{s=1}^{S} X_{fi}^{ks} = \sum_{i=1}^{n} \sum_{j=1}^{m} X_{ij}^{k} \qquad (5)$$

determine the optimum plan of location of the given production.

When locating the particular facilities for the production of machinery, equipment and instruments for the northern zone it is essential to include the economic effect arising from the unification of thermal and electric power facilities, and auxiliary services in the machine-building complex or centre.

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SOME ASPECTS OF JOINT DEVELOPMENT OF INDUSTRY AND AGRICULTURE UNDER NORTHERN CONDITIONS

Quite often one hears the opinion that, since agriculture has an insignificant share in the developing industrial regions of the North, matters connected with this sector do not deserve serious attention. Such views cannot be accepted.

It is necessary to bear in mind not only the relationship between the gross product of industry and agriculture, but also the size of the urban and rural population, especially the numbers of those engaged in the two sectors of production. For example, in the Yakut A.S.S.R. in 1970 less than 20% of the gross output in the Republic came from agriculture, while the proportion of rural population amounted to 43% of the overall population. In 1970 the proportion of people engaged in agriculture was 23.2% of the overall number of people employed in the production of goods, which is only slightly below the percentage of industry, which amounted to 24.7%.

It is also necessary to remember that the rural population in a number of regions in the North (Yakutiya, Chukotka, national okrugs of Krasnoyarsk Krai, Tyumen Oblast, and other regions) is made up of indigenous people. This imparts special features to the cooperation between industry and rural activities. In some regions of the North, populated by a significant proportion of indigenous people, who still maintain a nomadic way of life in some places, the main rural economic activity is reindeer herding, trapping, hunting and fishing. In these same areas a modern industry, equipped with the latest machinery and equipment, is being established and workers' settlements, provided with modern accomodations and cultural services, are being built. Under these conditions the historical problem of overcoming the considerable

Problemy Severa, (18): 154-158, 1973.

differences between urban and rural areas is of a special nature. Specifically, the urban population must play an important role in fundamentally changing the life and culture of the indigenous population by raising them to the level of that of the urban population.

The problem of integrated development of rural activities and industry in the North must first of all be considered as an important factor in raising the economic efficiency of opening up the North and solving wide social and economic problems associated with it.

It is accepted that a sectoral administration of industry and rural activities is essential in order to carry out an up-to-date technological policy, bearing in mind the special features of each sector of production. As has been stressed in the XXIV Congress of the C.P.S.U., it is essential to combine sectoral and territorial planning rigorously to achieve an efficient development of the national economy of the U.S.S.R. This is of great importance to remote northern regions. Administration by sectors under conditions of inadequate territorial planning often leads to serious disparities between the development of specialization sectors and support and service sectors. This also results in shortcomings in the use of labour and natural resources. Specifically, departmental administration, born from the predominance of administration by industrial sectors, frequently results, for example, in construction bases being formed by a given industry only to serve their own industrial enterprises, without taking into account the needs of agriculture and other sectors of the local economy. Logging in some mining regions of Magadan Oblast and Yakut A.S.S.R. has resulted in harm to fur-bearing animals and has in some cases upset the ecological balance.

In the North there is no formation of agro-industrial complexes of the type that are to be found in Moldavia, southern Ukraine, and other southern and central regions of the country. In the northern regions, where, on account of natural conditions, there is no large-scale agricultural production of inter-regional importance which could supply raw materials to the food industry, only relatively small combined enterprises can be formed for the production and processing of animal husbandry products (meat, milk), and also of auxiliary enterprises in state and collective farms for the processing of reindeer skins and

the production of fur products. Furthermore, it is essential to ensure an efficient utilization of labour resources on account of the prevailing shortage of labour in the North.

Within the northern zone large enterprises engaged in the production of animal husbandry products were established and should continue to grow. These are organized on an industrial scale (large complexes for the production of meat and milk, and greenhouse production) in order to provide the population of the North with fresh and difficult-to-transport food products. The organization of such enterprises should be based on the maximum mechanization and automation of all the production processes using the most advanced technology.

Another feature of the cooperation between industry and agriculture in the North is the isolated, focal nature of development, and the remoteness of these isolated centres from the regions where agriculture is already developed. This has resulted in the formation of specific forms in the organization of agricultural enterprises, such as subsidiary farms, created so that they would supply the population of these industrial centres with fresh milk, potatoes, vegetables, and other food products that are difficult to transport. The main position in the complex is occupied not by agriculture, but by industry. The task of the complex is to produce its industrial product, and the provision of agricultural products to the people employed in it is of secondary importance. This form can be conventionally called an industrial-agricultural complex. To a greater or lesser extent such complexes have already been formed in Yakutiya, Komi A.S.S.R., Magadan Oblast, in the north of Krasnoyarsk Krai and in other regions of the North. Some industrial enterprises in other zones of the country also have subsidiary farms, but they are not well developed and do not play such an important role as in the North. This can be seen from the comparative analysis done by us, in spite of the fact that it is difficult to make such an analysis because of the lack of periodic state statistical records for state and subsidiary farms administered by industrial enterprises. Data about these types of farms are included under the heading "kolkhoz, sovkhoz, and other state-administered farms", or for some indexes of animal husbandry under the heading "other state and cooperative farms". But even in this last grouping along with subsidiary farms of industrial enterprises there are farms of consumer cooperatives, farms

run by medical sanitariums, rest homes and medical institutions, research and experimental farms of academic and research institutions, and so on. As a result, it is impossible to single out data referring only to subsidiary farms.

The only index of the state statistical service, which is given separately for sovkhozes and subsidiary farms belonging to industrial enterprises, is the one referring to the number of breeding cattle and poultry (according to the returns made for January 1 of every year in respect of the subsidiary farms of the principal industrial ministries). According to the data from these records, the absolute and relative numbers of cattle in the farms of industrial enterprises in the northern zone, and probably also in the production of animal products, is many times larger than the average for similar farms in the R.S.F.S.R. and for the oblasts of the Central zone.

An analysis of the data in the table shows that whereas on the average for the R.S.F.S.R. the number of cattle in sovkhozes and subsidiary farms in industrial enterprises is 0.31% of the number in all types of farms, in the six oblasts of the North this ratio varies from 1.1% in Arkhangel'sk Oblast to 40.3% in Murmansk Oblast. The number of pigs on the subsidiary farms of industrial enterprises in relation to all the categories of farms is lower only in Kamchatka Oblast than for the R.S.F.S.R. as a whole; in all other oblasts it amounts to 8.4 - 16.7%.

Of some interest also is a comparison between the number of stock in the sovkhozes and subsidiary farms of industrial enterprises belonging to ministries other than Agriculture, and in the sovkhozes of the Ministry of Agriculture of the R.S.F.S.R. For cattle this ratio on the average for the R.S.F.S.R. is 0.9% of which 1.1% is for cows. For the oblasts in the North the figure varies appropriately from 1.9% to 167.5% and from 2.1% to 192.5%. This tendency is expressed even more strongly in pig and poultry breeding. Sovkhozes and subsidiary farms of industrial enterprises on the average for the R.S.F.S.R. have only 1.7% pigs and 1.8% poultry in relation to their numbers in the sovkhozes of the Ministry of Agriculture of the R.S.F.S.R. In some oblasts of the North the farms of industrial ministries have 1.5 - 3.7 times more pigs than the sovkhozes of the Ministry of Agriculture of the R.S.F.S.R., and for poultry the

Table

Relative numbers of breeding animals and poultry in the sovkhozes and subsidiary farms of the principal industrial ministries as of January 1, 1971

Region	Number of farms belonging to industrial enterprises which have breeding stock	No. of stock in sovkhozes and subsidiary farms of industrial enterprises in %							
		No. of stock in all categories of farms, in %				No. of stock in sovkhozes of the Ministry of Agriculture, R.S.F.S.R. in %			
		Cattle	Cows	Pigs	Poultry	Cattle	Cows	Pigs	Poultry
Yakut A.S.S.R.	36	2.2	3.3	13.0	61.2	3.8	5.9	370.0	158.8
Magadan Oblast	34	8.5	8.1	10.9	5.9	11.1	10.5	149.2	7.1
Kamchatka Oblast. . . .	15	7.4	8.0	0.1	8.1	9.5	10.3	0.2	12.5
Komi A.S.S.R.	92	13.7	14.1	8.4	24.2	26.1	33.1	43.1	32.9
Murmansk Oblast	12	40.3	42.9	15.8	52.6	167.5	192.2	66.9	165.3
Arkhangel'sk Oblast . .	96	1.1	1.2	16.7	4.2	1.9	2.1	164.5	5.1
Average for R.S.F.S.R.	-	0.31	0.35	0.5	1.27	0.9	1.1	1.7	1.8

figure varies from 5.1% in Arkhangel'sk Oblast to 165.3% in Murmansk Oblast.

It is quite obvious that in the northern regions of the R.S.F.S.R. the relative contribution of the farms of industrial enterprises in animal breeding is many times higher than in other oblasts, and in a number of cases their production is greater than that of sovkhozes of the Ministry of Agriculture of the R.S.F.S.R.

Of considerable interest are data that show the share of farms of industrial ministries in the supplying of products that are difficult to transport. In the absence of systematic records we have been able to gather in the Ministry of Trade of the Yakut A.S.S.R. only some statistical data for three years (1969 - 1971). An analysis of these data shows that the contribution of these farms in supplying the corresponding industrial enterprises with potatoes increased from 8% in 1969 to 14.1% in 1970. In the supply of vegetables this contribution amounted to 42%, including cabbage, from 50.7% to 65.7%, and cucumbers, from 29.5% to 51.2%.

It would be appropriate to note here that the contribution of kolkhozes and sovkhozes of the Ministry of Agriculture of the Yakut A.S.S.R. to meet the demands of industrial enterprise workers was, as a rule, lower than that of subsidiary farms, and that it tends to show a relative decline. Thus, in 1969 the contribution of kolkhozes and sovkhozes in the overall sales of potatoes by Workers' Supply Boards amounted to 7.9%, as against 8% provided by the subsidiary farms. In 1971 these figures were 10.4 and 14.1% respectively. In the sale of cabbage by the Workers' Supply Boards of industrial enterprises the contribution of kolkhozes and sovkhozes in 1969 was 27.1% as against 65.7% for subsidiary farms. In 1971 the figures were 20.8% and 50.7%.

The data provided by us testify to the fact that the sovkhozes and subsidiary farms of industrial enterprises play an important role in supplying the people working in industry with fresh and difficult-to-transport products of agriculture, and that such a form of cooperation between agricultural and industrial production is especially characteristic of the northern regions.

This type of combination of industry and agriculture is of importance in the formation and consolidation of the population and the labour force in the North and should be fostered in every way. However, the system of planning, accounting and production administration in the subsidiary farms, the materials and technical facilities supplied to them, and the specialists placed at their disposal, need to be improved to a considerable extent. A positive solution to these problems will make it possible to increase substantially the economic efficiency of operating these farms, and strengthen their role in the development of the North.

There is also a need to improve the location and specialization of existing agricultural production in the North so that better use could be made of its possibilities to improve the supply of fresh products to the population of the industrial regions. Specifically, substantial unexploited possibilities exist in the Yakut A.S.S.R. Up to now insufficient use has been made of the potential of farms in the Lena, Olekma, Suntar and Leninskii regions to improve the supply of farm products (especially of potatoes and vegetables) to workers in the diamond industry. These products are imported from other regions in large quantities by the Workers' Supply Board of the "Yakutalmaz" Association*. A more intense specialization by the farms of the Lena and Olekma regions, and in part also by those in the Leninskii and Suntar regions where conditions are especially good for the growing of these products, would make it possible to dispense with imports of potatoes, and to a substantial extent also of vegetables.

The same can be said of other agricultural regions adjoining the gold and tin-mining region, the newly developing natural gas industry and other sectors. The development of agriculture in industrial regions will lead to the establishment of closer links between kolkhozes and sovkhozes gravitating to the regions of industrial development and industrial enterprises. It will result in strengthening social and cultural assistance and other forms of help given to these farms. Even under the existing conditions of irregular contacts between industrial enterprises and kolkhozes and sovkhozes which supply them with

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* Diamond mining association. (Transl. Ed.)

agricultural products, some enterprises have been rendering considerable assistance to agriculture. For example, the "Indigirzoloto" combine of the "Yakutzoloto" Association* is currently building a complex consisting of agricultural, residential, cultural, and consumer service buildings at the central settlement of the "Oimyakonskii" sovkhoz. During the current five-year plan a House of Culture, diesel power plant, and a barn for 200 cows are to be built. Using the resources of the combine, 300,000 - 350,000 rubles worth of construction work is to be done in the sovkhoz annually. The main settlement of the sovkhoz is gradually growing into a townsite.

The "Yakutzoloto" Association enterprises also give kolkhozes and sovkhozes assistance by helping them to train workers engaged in mechanized production and in the repair of machinery and equipment, and help with cultural and education activities at the settlement.

A more efficient utilization of the existing possibilities to increase the production of fresh agricultural products in kolkhozes and sovkhozes located near industrial regions, and the establishment of permanent relations between industrial enterprises and these units will create favourable conditions for a faster development of agriculture in these regions, and will tighten the links between industry and agriculture.

An improvement in supplying the population of industrial centres with fresh agricultural products will help in solving one of the important problems of developing northern territories, namely, the stabilization of a labour force. At the same time technological progress and an increase in labour productivity in kolkhozes and sovkhozes will result in the freeing of labour resources from agriculture and channeling them into industry. This will aid in building up a working class in the local population.

The experience in close links and cooperation between industrial enterprises and kolkhozes and sovkhozes shows what a beneficial effect such links have on social development, initiation of agricultural workers in the methods

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* Gold mining association. (Transl. Ed.)

of industrial organization and work standards, and improving cultural and community services.

The modification, under northern conditions, of agricultural-industrial complexes into an industrial-agricultural complex is one of the forms of combining industrial and agricultural production, and it deserves the special attention of the administrative and planning authorities and scientific research organizations. Even the most superficial examination of this process reveals a number of problems, some of which are of an organizational nature and should be solved in an administrative manner; others require scientific analysis and recommendations of scientists.

IV. THE PROBLEM OF SETTLEMENT

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SYSTEMS OF SETTLEMENT AND PROTECTION OF THE ENVIRONMENT IN THE NORTH*

With the accelerating rates of development and growth of the regions making up the North, increasingly large contingents of workers are being attracted there. In view of this, rational settlement and the associated question of environmental protection is becoming one of the main problems of northern town planning. On the correct solutions of the problem depend not only the establishment of favourable living conditions for the population, but also, in large measure, the efficiency of capital investments.

The following are the main tasks facing town planners working on problems of settlement in northern regions:

Determining ways of improving upon the pattern of settlement that has evolved;

Identifying the principles governing settlement in newly developed regions;

Paying attention to the protection of the environment.

In the initial stage of the industrial development of the North, the principle that governed the establishment of populated places was "living accommodation within walking distance of the place of employment". As a result, there arose a large number of small, self-contained, at times temporary and inadequately equipped settlements, which were not connected with one another from the standpoint of function and layout.

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* The papers presented in this section have been written as a subject for discussion.

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Gradually, in industrial centres where there are long-established enterprises, groups of settlements emerged which are held together by technical-industrial, social, and manpower links between the villages. This applies primarily to the Noril'sk, Vorkuta, and a number of other industrial centres in the Kola region of the North.

An analysis of this group dispersal of communities has made it possible to identify a number of the advantages it offers over autonomous settlements, both in the organization of industrial output and in improving the work, lifestyle, and recreation of the inhabitants:

1. An important economic benefit is achieved from the concentration of industry, and from the amalgamation and cooperative efforts of small enterprises and establishments, departmental transportation and power-generating facilities and installations;

2. The conditions under which labour resources are used become more favourable on account of the possiblity of redistributing them;

3. The necessary conditions are set up for the enlargement of construction bases and further industrialization of housing construction;

4. The provision of cultural and social amenities becomes more efficient and relatively uniform when the population being served is in the form of a group, irrespective of the size of the communities constituting it;

5. A wide choice of occupations develops, and changes in employment are made possible.

The singling out of these and other advantages has made it possible to conclude that group formations are a more progressive type of settlement than are autonomous communities. The spontaneous process that has led to the formation of groups of settlements in the most developed regions of the North - on the Kola Peninsula, in the Komi A.S.S.R., in the northern part of Krasnoyarsk

Krai and elsewhere - affords a basis for concluding that small autonomous communities which have formed a scattered pattern until recently are incapable of meeting the constantly increasing socio-economic requirements of the inhabitants of the North. This is beginning to be replaced by the more progressive group principle of settlement, based on inter-village links.

By a system of settlement we mean the entire spatially oriented socio-economic and systematically planned developement of interlinked communities and industrial installations in which the movement of large numbers of people can occur.

As distinct from a group of communities, and particularly from autonomous communities, a systematic settlement is more stable in the long term. It can prevent the disappearance of well-organized communities which occurs when the individual mineral deposits at the site of whose development they were built become exhausted. This can be achieved by virtue of a change in the functions of the particular communities that go to make up the system of settlement.

A comparison was made between some of the economic factors involved in isolated autonomously developing communities and systems of settlement in the course of drawing up a systematic free-hand plan of the industrial centres of Murmansk Oblast, the Komi A.S.S.R. and Magadan Oblast. This has made it possible to arrive at the following tentative conclusions with respect to improving the work, lifestyle and recreation of the population.

With the concentration of industry in systems of settlement there is an enhancement of the over-all efficiency of individual industrial installations and of the work of the industrial and manufacturing complex, considered as a whole. This leads to higher labour productivity indices, and accordingly to an increase in the salaries earned by the workers.

With the systems approach to settlement it becomes more advantageous to set up new industries based on the integrated processing of raw materials

and on utilizing and exploiting fully all of the industrial waste products. This sets the stage for a significant increase in the output from a given volume of raw material, coupled with effective protection of the environment. Given the existence of several interdependent enterprises, preferential conditions are set up for the building of special teaching institutions for the training of local workers, for the mechanization and automation of the transportation and warehousing facilities, and for the development of a common transportation network, power supply system, and engineering services.

Furthermore, the unification and enlargement of industrial installations and the delimiting of individual industrial zones make possible an interlocking of buildings and industrial plants. This results in a saving of up to 5% in the cost of constructing the industrial buildings. By reason of the compactness, moreover, a saving of up to 15% of the areas being developed is achieved, and there is a decrease of up to 15% in the length of the roads leading to the industrial installations, and of up to 22% in the length of the access railroads.

With an increase in the output of a large-panel house building factory of from 35,000 m^2 of living space annually in the case of an autonomous town to 150,000 m^2 of living space annually with the systems method of settlement it is possible to lower the cost of the construction components by approximately 10%, with the result that the unit capital investments are decreased from 110 to 82 rubles per m^3 of precast concrete.

The systems approach to settlement yields the following increases in the capabilities for meeting the requirements of the population: for administrative services (at currently existing standards), by up to 30%; for cultural amenities, by up to 40%; for trade, by up to 45%; for domestic service, by up to 90%; for playing fields and sports pavilions, by up to 25%; and for communal dining halls, by up to 45%.

Advantages also exist with respect to meeting the recreational needs of the population. These consist in the fact that, in addition to the brief daily period of recreation in the open air, with the systems method of settlement it is

possible to provide for protracted periods of recreation.

In a system of settlement by utilizing waste heat it is possible to achieve a more economical arrangement of large subsidiary agricultural units which are capable of supplying the population with a wide assortment of cheaper vegetables.

As is well known, the supply and equipping of industrial workers in the North is more expensive than in other regions of the country. It is therefore advisable to make the fullest possible use of existing labour resources. In isolated settlements, especially those of the timber and mining industries which are taking shape in the North, full utilization of labour resources is unachievable because of the limited opportunities for using female workers.

The analysis of the industrial centres in the North has made it possible to trace the process of transition from autonomous communities to groups, and subsequently to systems of settlement. For example, the development of links within the Pechenga industrial centre (the redistribution of cultural and welfare services and of public recreational facilities, having regard to the group as a whole, the emergence of the town of Zapolyarnyi as the centre of the group) establishes the conditions which are necessary for the development of inter-village cultural and welfare facilities and the formation of a group in place of the communities which have hitherto existed autonomously.

In the Murmansk group it is possible to observe an even higher degree of organization. Here, 60% of the travelling done by the inhabitants consists of journeys connected with their work, and each community is fulfilling a definite function with respect to the group of settlements as a whole. This gives us the right to consider the Murmansk group as being currently at a transitional stage in the process leading to a system of settlements. Within the transitional stage between the grouped arrangement of communities and systems of settlement we can place the Khibiny, Vorkuta and Noril'sk industrial centres, in each of which a commonness and interdependence in functional structure between the communities is to be seen.

In the industrial centres of the North a decrease in the number of small settlements due to the establishment of towns is also to be noted. Experience in the operation of industrial centres has shown that the mobility of skilled workers in towns is several times less than in small settlements. Using as an example an analysis of the mineral deposits of the Susuman region of Magadan Oblast, it has been demonstrated by economists of the Leningrad Research Institute of Town Planning (LenNIIPgradostroitel'stvo) that from the standpoint of economic costs, settlement in a large town is more advantageous than in many small communities, even in those cases when the workers are transported by air from the town to the places of employment.

The analysis of the prospects for settlement in the North, having regard to the sociological forecasts with respect to the growth of society, and scientific and techological progress confirms the desirability of the consolidation of communities. Here, however, we must not lose sight of the existence patterns of the smaller communities, such as small single-industry towns based on isolated outlying mineral deposits, and the various permanent and temporary settlements.

It should be noted that for a long time the opinion was held that the North could be developed by constructing a large number of small settlements. Towns such as Noril'sk, Vorkuta, Magadan and others were regarded as an exception to the general rule. A concept such as this gradually loses its supporters. It has come to be replaced by a new one that envisages fewer but larger towns or centres, where the inhabitants will be more fully able to satisfy their spiritual and physical needs. For example, it is envisaged by the planning organizations at Vorkuta and Noril'sk that instead of the existing 16 and 20 communities in these industrial centres, there will be 3 or 4 urban developments in the future. In the process, the total number of inhabitants in these industrial centres may be increased as a result of the development of new mineral deposits. But the basic principle of settlement in industrial centres of newly developed regions must be the systems approach to settlement, where the towns will be the administrative-political and cultural-economic centres of the districts.

Preliminary studies of various specific situations, associated with the geographic position, the prevailing natural and climatic conditions,

and the socio-economic prerequisites, with parallel consideration given to scientific and technological progress in construction, transportation, power engineering, and mining have made it possible to identify the following four prospective varieties of systems of settlement: group, expeditionary, shuttle and mixed. Examples of three of these are illustrated in Figure 1.

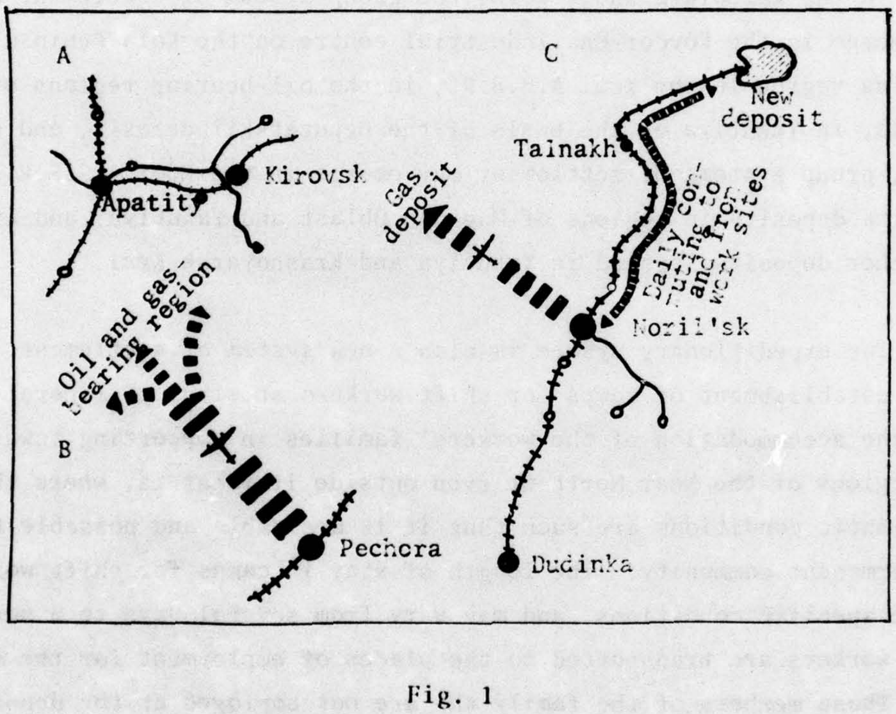

Fig. 1

Examples of systems of settlements envisaged

A - group (Khibiny); B - expeditionary (Pechora);

C - mixed (Noril'sk)

It is envisaged that the group system of settlement, constituting an improvement upon the existing form of settlement, could be planned and implemented through the establishment of new industrial centres which would remain in operation for a long time to come. The basic principle of this system is that the places of employment and residence must be readily accessible to one another through the medium of mass transportation facilities. This means that large numbers of people must be expected to move daily between all of the communities by reason of their occupational and cultural interests, and that each settlement will fulfill definite functions, as an integral part of the whole.

In the immediate short term, the group system of settlement may be expected to emerge in the Kovdor-Ena industrial centre on the Kola Peninsula, in the Ust'-Tsil'ma region in the Komi A.S.S.R., in the oil-bearing regions of Western Siberia, in Yakutiya on the basis of the Deputatskii deposit, and elsewhere. Later, group systems of settlement may emerge in the Komi A.S.S.R., at sites at bauxite deposits in regions of Magadan Oblast and Yakutiya, and at the oil gas and other deposits located in Yakutiya and Krasnoyarsk Krai.

The expeditionary system is also a new system of settlement. It envisages the establishment of camps for shift workers at sites of mineral deposits and the accommodation of the workers' families in supporting towns situated in regions of the Near North or even outside it, that is, where the health and climatic conditions are such that it is desirable and possible to establish a permanent community. The length of stay in camps for shift workers depends on the specific conditions, and may vary from several days to a month or more. The workers are transported to the places of employment for the most part by air. Those members of the family who are not employed at the deposits live under normal natural and climatic conditions. This system of settlement is, in the main, most suited to the development of mineral deposits in the undeveloped far northern regions, where the natural conditions are particularly complex. Furthermore, it provides for the existence of a construction base in the support town where the housing for the shift workers' camps is manufactured. The expeditionary system of settlement is applicable not only under extremely rigorous natural conditions but also in the event of it being necessary to work small deposits with very short periods of exploitation where the building of

permanent settlements is undesirable.

The shuttle system of settlement, entailing separate positioning of the industrial and residential parts of the town, can be regarded as a variant of the expeditionary system. This system can become established when the work sites are subject to particularly unfavourable microclimatic conditions, unsuitable for settlement by families, in which case an area with more satisfactory microclimatic conditions (e.g., sheltered by the surface topography) can be selected for settlement within a radius of 100 - 300 km. With this system of settlement the workers will be required to commute daily to the work sites, using rapid means of transportation (aircraft, helicopters, monorail systems, etc.).

Finally, we have the mixed system of settlement, which can exist as an independent variety and embodies in various combinations the components of the other systems of settlement: the group, the expeditionary and the shuttle systems. This is the most flexible, dynamic and efficient system, as it can have all of the advantages of the individual systems of settlement so as to fit the specific conditions. The upgrading of the mixed system is dependent on perfecting the components of the systems of settlement that constitute it.

The Noril'sk industrial region can be cited as an example of the mixed system of settlement. In the very near future a component of the expeditionary system of settlement may be coupled with this system on the basis of the exploitation of gas deposits. Furthermore, there are prospects that a component of the shuttle system will spring up on the basis of a newly discovered deposit of nonferrous metals lying to the north of Talnakh. This will take place if, during the course of the current adjustment of the general plan, old-style low-rise housing is replaced by multistorey buildings and the population of the base town is increased. If this were to happen, it would obviate the need to build yet another inadequately equipped town as was planned.

Along with the systems of settlement in the North, there are legitimate reasons for the existence of separate, territorially remote and isolated specialized settlements, for example, those that have a role in the power engineering, meteorological, and transportation services. It is envisaged that any of these

towns or settlements could become part of a closely knit developing system of settlement, assume additional functions, and become a constituent component of it.

The formation of new systems of settlement differs qualitatively from improving the existing pattern of settlement as it calls for considerable preparatory work and the provision of transportation facilities in the regions of the North. It also presupposes the operation of a large number of temporary settlements fully equipped with engineering services. These require mobile and relocatable prefabricated residential and community buildings. This gives rise to a need for setting up a network of suitably equipped construction bases in the mid-latitudinal zone of the country. The structures produced at these bases must be composed of light materials, the components of which could be delivered by air.

It can be assumed that what is being envisaged for the immediate future will be basically only a preparatory and experimental phase with a view to the eventual large-scale realization of the new systems of settlement we have been discussing. It will be the existing group formations, some of which are being converted into systems of settlement, that will undergo the greatest development during this period. Among these are the Murmansk, Pechenga, Monchegorsk and Khibiny group in the Kola region of the North, the Vorkuta and Ukhta group in the northern part of the Komi A.S.S.R., the Noril'sk group in the northern part of Krasnoyarsk Krai, the Yakutsk and Aldan group in Yakutiya, the Bodaibo group in Irkutsk Oblast, the Magadan, Bilibino, Pevek and Anadyr group in the northeastern part of the country, etc.

Based on the socio-economic and technical progress achieved, the types of settlement will be continually modified and improved upon, thus corresponding to the constantly increasing demands of the population in terms of their industrial, living and recreational needs. In this connection it is already possible to discern a trend towards new, more developed and more complete formations in the structure of existing settlement.

Based on common production specialization and recreation facilities and the formation of cultural, social, occupational, and other links, a trend

towards cooperation is observed between groups, especially between those that are in a stage of transition to systems of settlement. This trend is particularly marked in groups of communities, such as the Khibiny group, the Monchegorsk and Kovdor group, the Vorkuta and Inta group, the Syktyvkar and Mikun group, and the Magadan group.

The centralization of administration, provisioning, and planning of certain sectors of the economy, and of cultural, political and scientific life is dictating a further expansion in the scope of this interdependence, even to the extent of whole regions. In this connection, forecasts of advances in town planning, taking into consideration scientific and technological progress and the regional peculiarities of the North, have made it possible to identify the following territorially and economically coordinated systems of settlement: local, regional and interregional.

Local systems of settlement are limited to coordinated intercommunity ties occurring within a single industrial centre. They include the aforementioned developing and contemplated systems of settlement. A rapid growth of the ties between groups of communities, and thus also between local systems of settlement within a single region, may lead to their unification and the formation of regional systems of settlement. A regional system of settlement may include several subordinate administrative regions, or an entire oblast. For example, the Murmansk Oblast, which is already emerging as a single region with interdepartmental administrative, economic, cultural, scientific, power supply, transportation and industrial-technological management, coupled with close ties between groups of communities, can be envisaged as corresponding to the Kola regional system of settlement (Figure 2).

Considering the potentialitites for economic development, in the Komi A.S.S.R. the same principles can be used for identifying the Vorkuta, Pechora, Ukhta, and Syktyvkar regional systems of settlement, each of which will include several administrative regions. Moreover, the Pechora regional system of settlement, which takes in the regions of the Timan-Pechora oil- and gas-bearing province, will probably extend beyond the Komi A.S.S.R., and take in areas of the Nenetskii National Okrug (Figure 3). The development of

territorial-industrial complexes and systems of settlement should not be hindered by the administrative boundaries of regions and oblasts. The latter may even be adjusted, arising from the expediency of the economic and administrative tasks of the territorial-industrial complexes in question.

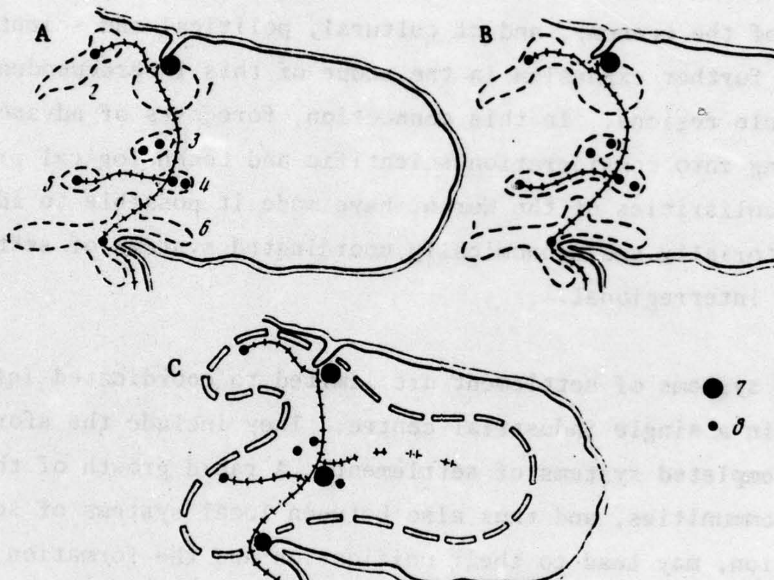

Fig. 2

Stages in the formation of the Kola regional system of settlement

A - group positioning of communities: 1 - Murmansk group; 2 - Pechenga group; 3 - Monchegorsk group; 4 - Khibiny group; 5 - Kovdor group; 6 - Yuzhnaya group;

B - merging (unification) of groups of communities;

C - development of a regional system of settlement: 7 - base towns of Murmansk, Apatity and Kandalaksha; 8 - single-industry towns of Zapolyarnyi, Monchegorsk, Olenogorsk, Kirovsk and Kovdor

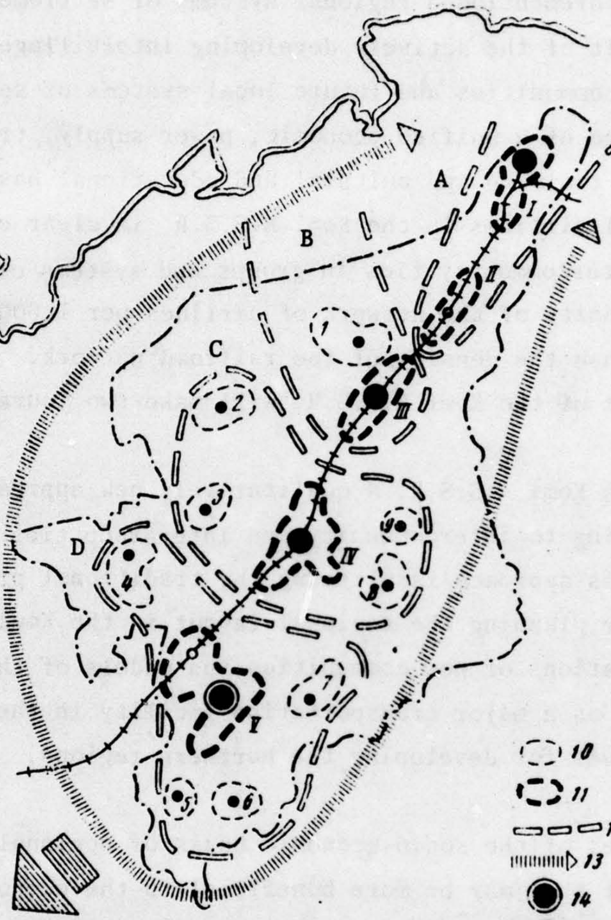

Fig. 3

Prospective settlement in the Komi A.S.S.R.

1 - 9 - possible formation of the following new groups of communities: Usinsk, Ust'-Tsil'ma, Boksit, Koslan, Ob'yachev, Koigorod, Ust'-Kuloma, Troitsko-Pechorsk, Vuktyl;

I - V - formation of the following local group systems of settlement: Vorkuta, Inta, Pechora, Ukhta, Syktyvkar;

A - D - approximate formation of the following regional systems of settlement: Northern (Vorkuta), Pechora, Ukhta and Syktyvkar;

10 - tentative boundaries of the groups; 11 - tentative boundaries of the local systems of settlement; 12 - tentative boundaries of the regional settlements; 13 - tentative boundaries of the interregional (Komi A.S.S.R.) system of settlement; 14 - supporting town of Syktyvkar; 15 - base towns of Vorkuta, Komsomol'skii, Pechora and Ukhta; 16 - industrial towns - the centres of a group of communities and local systems of settlement (Inta, Vuktyl and Usinsk)

The aforementioned regional systems of settlement in the Komi A.S.S.R. are a result of the actively developing intervillage ties between existing groups of communities and future local systems of settlement, and also of the existence of a unified economic, power supply, transportation, medical, scientific training and cultural and educational base. The rapid development of local airlines in the Komi A.S.S.R. is clear evidence of the strengthening of intercommunity ties in groups and systems of settlement. At the present time the density of the network of airlines per 1,000 km^2 of area is six times greater than the density of the railroad network. It is estimated that each inhabitant of the Komi A.S.S.R. will make two journeys by air annually.

In the Komi A.S.S.R. a qualitatively new approach to the solution of problems pertaining to intercommunity and intergroup ties using air transport is being noted. This approach is altering the traditional principles that have formed the basis for planning the regional layout in the Komi A.S.S.R. and deciding on the locations of new communities and models of them. The introduction of aviation as a major transportation facility in the Komi A.S.S.R. is opening up new avenues for developing the northern regions.

Studies of the socio-economic basis of regional systems of settlement have shown that they may be more beneficial to the economy and in improving the living standards of the population than are local systems of settlement. The advantages they offer are in the scale of the industrial activity, the standard of the services provided, the possibility of forming constructive contacts and the improved capability for exchanging information.

Interregional systems of settlement are predicated on the economic and social ties between neighbouring regional systems of settlement. They may come into being primarily on account of the division of labour. A northern region, as a rule, is pre-eminently the site of a main field of specialization while the regions situated farther south or in the Near North are where the services that support it are located (the repair and construction facilities, food supply bases, etc.). Having regard to the current development of the North, interregional systems of settlement may spring up between the Kola North and Karelia, between the northern and southern regions of the Komi A.S.S.R.

and between those of Krasnoyarsk Krai. The expediency of such a distribution of labour is proven by economic comparisons made at LenNIIPgradostroitel'stvo which have shown, for example, that under northern conditions the production of certain components and parts of vehicles and also repairs to machine components are, as a rule, ten times more expensive than in the central zone with transportation of the components by air to the places where they will be used in the North.

Interregional systems of settlement may also come into being in cases where there is simultaneous integrated development of large areas. A possible example is the current development of the oil-and gas-bearing regions of Western Siberia where, on the basis of economic and urban development, three oblasts (the Tyumen and, in part, the Tomsk and Omsk oblasts, with a total area of more than 1,500,000 km^2) are to be immediately amalgamated into an interregional system of settlement.

In the regions of the North, settlement is closely linked with the developed regions of the central zone. Forecasts of economic growth and urbanization have shown that the northern regions cannot be regarded as isolated entities situated outside this link-up. The main direction envisaged in long-term plans for the development of the North has been from the south through the development of supporting towns located in the central zone and situated along the Trans-Siberian trunk railroad.

It can be expected, moreover, that as a result of continuing scientific and technological progress, the Northern Sea Route will be a year-round shipping artery and that the ports on the coast of the Arctic Ocean will become important cities which will be transformed into major centres for the development of the natural resources of the adjoining areas.

At the present time we can designate the following main types of communities which will constitute the aforementioned systems of settlement:

1. Supporting towns (such as Tyumen, Tomsk and Krasnoyarsk) situated outside the northern zone or at its boundaries (such as Petrozavodsk,

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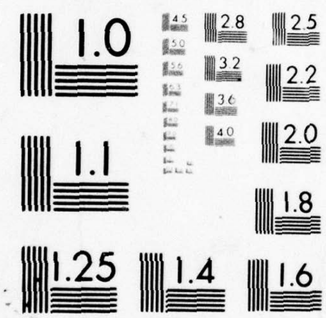

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Syktyvkar, Surgut, Yakutsk and Magadan) which will be centres of interregional systems of settlement and main bases for the development of the North;

2. Base towns (such as Murmansk, Apatity, Kandalaksha, Vorkuta, Ukhta and Noril'sk) - centres of territorially isolated industrial complexes, and of local and regional systems of settlement;

3. Industrial towns (such as Zapolyarnyi, Monchegorsk, Dudinka, Inta, Pokrovsk and Susuman) being for the most part single-industry towns;

4. Industrial settlements of both the permanent and the temporary types (such as shift-work, mobile, and relocatable camps) fully equipped with engineering services.

The protection of the environment is closely linked with the organization of the communities in the North. Environmental protection measures are of immense importance in the North, and if the systems approach to settlement is used, they can be implemented more widely and to better effect than has hitherto been the case in separate autonomous communities. In systems of settlement it is easier to arrange for control over the quality of the environment and to find the necessary means for instituting effective preventive measures.

One of the principal measures for protecting the environment is the development and use of correct methods of constructing and operating buildings and installations in permafrost areas. This applies especially to industrial installations where technological processes entail the release of large quantities of heat and water. The incorrect operation of buildings and installations constructed on permafrost leads to subsidence of the ground, to karst phenomena, and to subsequent partial or total destruction of the buildings.

In order to prevent the occurrence of undesirable phenomena it is recommended that the natural vegetative cover be retained, as this serves as a protective thermal insulating layer that maintains the frozen ground in its natural state. Disturbance of the natural cover can lead to an increase in the depth of the active layer, to a build-up of water and consequent stream formation,

and eventually of undesirable bodies of water and gullies within the areas being developed.

The conditions in the North are such that trees and shrubs grow much more slowly than is the case in the central zone. In most of the northern regions planted trees will not survive. It is therefore necessary, when constructing settlements, to eliminate tree felling and in general adopt a careful policy with respect to the natural vegetation.

The retained tree cover can also be killed through incorrect use of construction areas. This is because the rooting system of trees in the North lies very close to the surface, in the active layer, which only thaws to a very moderate depth in summer. Thus, trampling of the ground close to trees results in damage to the roots.

Trees, particularly conifers, suffer greatly from the effects of air pollution. The positioning of industrial enterprises should therefore take cognizance of the prevailing wind direction, both with respect to the residential areas and the expanses of green. It is very important to have smoke and gas traps, and also installations that recycle harmful wastes.

In connection with the immense difficulties associated with efforts to restore the vegetation in most of the regions of the North, an important measure must be the development and protection of attractive terrains, both within the boundaries of the settlements and beyond them. Special attention must be paid to the establishment of zapovedniki, to the protection of indigenous plant species, and to the acclimatization of new species.

Protection of the surrounding terrain, the establishment of resistant tree plantations, and also the development of small parks and landscaped areas are necessary from the standpoint of their inclusion in the urban environment so as to provide for spacious artistic blendings.

Experience gained in the building up of settlements has shown that

very often the embankments are occupied by port and warehousing facilities and by industrial and other installations which prevent access from the areas undergoing development to the water bodies. This spoils the appearance of towns. In future,therefore, it will be necessary to build industrial and commercial installations away from housing developments, and to convert the embankments into visually pleasing architectural blendings.

The systems approach to settlement in the North facilitates the protection of the environment, the restoration of polluted water bodies and the preservation and expansion of green belts.

In future it would be advisable not to engage in the planning and building of autonomous settlements. The systems approach should be the basic principle in the building of towns in the North.

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PROBLEMS OF POPULATION CONCENTRATION IN URBAN SETTLEMENTS OF THE NORTH

The rapid rate of development of the natural resources of the North has led to a growth of the population in these regions, and pre-eminently of the urban population. Between 1926 and 1970 the total population of the Soviet North increased more than sevenfold, and during the same period the density of the urban population rose from 8 to 71%.

The northern regions of the country are characterized by a predominance of small towns and workers' settlements. This is a consequence of the priority which has been given to the development of the various sectors of the mining industry. Of 366 urban settlements existing in the North in 1970, 71 had the status of a town, and only seven of the towns had populations of more than 100,000.

One of the characteristics of the development of urban settlements in the North is the concentration of the population in the larger places. This trend, which has become more intensive during the last 10 to 15 years, has been brought about by the following factors.

1. The range of sectors of national economic specialization based on the large-scale exploitation of natural resources (oil, gas, and timber) has been expanded. This applies particularly to the Asiatic North, and is imparting a new character to the processes of its urbanization. The exploitation of these natural resources is characterized by a higher degree of urbanization than were such fields of specialization as the mining of nonferrous, rare and precious metals which predominated in the past;

Problemy Severa, (18): 170-176, 1973.

2. There is a greater degree of integration in the development of the economy of the North, which is manifested in the more complete use of the natural resources and particularly in the more thorough local processing of raw materials, as well as in the development of a number of service industries;

3. Better use can be made of labour resources which are both scarce and expensive in the North;

4. Technical advances in transportation make it possible to increase the travelling radius of settlement from the places of employment;

5. The central services of industrial centres and of the transport facilities serving the specialization sector are more concentrated, i.e., establishments where large numbers of workers are employed (for example, the production facilities of oil fields concentrate up to 40% of the total number of people engaged in oil production);

6. Conditions governing the location of establishments belonging to the service sectors of the economy are more favourable;

7. There are greater possibilities for making environmental improvements and, in particular, setting up favourable recreational zones for the population;

8. Unit capital costs are reduced for housing and municipal buildings, service facilities, and for effecting environmental improvements, and also the operating costs of municipal services are reduced* (under northern conditions, where high cost factors continue to be operative, this is of special importance).

Thus, under northern conditions, the process of concentrating people into larger settlements, dictated by the actual course of development

* According to V.G. Davidovich, the per capita efficiency-adjusted cost of the construction and operation of municipal services is minimal in cities with populations of between 50 and 100 inhabitants(1).**

** Sic. These figures should perhaps be 50,000 to 100,000. (Transl. Ed.)

of the economy, is highly efficient economically, and sociologically advantageous.

In order to determine the optimum degree of concentration of the population in large settlements it is recommended that an economic comparison be made between the different variants of settlement, using the following formula.

$$D_j = K_j + Э_j + \sum_{в=1}^{в} P^{в}_{mpj} + O_j^{mp} + \sum_{в=1}^{в} P^{в}_{k-kj} + O_j^{k-Б},$$

where

$Д_j$ - the total efficiency-adjusted costs with reference to the j-th variant of settlement;

K_j - the total expenditures on housing construction and construction for the provision of social services with reference to the j-th variant of settlement;

$Э_j$ - the sum total of operational expenditures pertaining to the use of municipal services in the j-th variant of settlement;

$P^{в}_{mpj}$ - the expenditures on travel to and from the places of employment in the j-th variant and using the $в$-th mode of transport;

O_j^{mp} - the cost of nonproductive time spent on travelling to and from the places of employment in the j-th variant;

$P^{в}_{k-Бj}$ - the expenditures on travel to meet cultural and domestic needs using the $в$-th mode of transport with respect to the j-th variant;

$O_j^{k-Б}$ - the cost of nonproductive time spent on travel to meet cultural and domestic needs in the j-th variant.

In contrast to the procedures that have been used until now for making an economic evaluation of the variants of settlement under northern conditions, in the light of the zonal wage coefficients being applied and the system of Arctic wage bonuses, this formula also takes into account the cost of nonproductive time spent on occupational, cultural and day-to-day travel by the inhabitants. Under northern conditions the latter factor has an important influence on the choice of the most economically efficient

variant of settlement. Suffice it to say that in the southern part of Magadan Oblast, for example, the cost per hour of nonproductive time, according to the calculations of LenNIIPgradostroitel'stvo, is 1.3 rubles.

In order to reveal the possible degree of population concentration in a smaller number of larger settlements under northern conditions, economic studies were performed at LenNIIPgradostroitel'stvo which entailed using the above-cited formula and applying it to a typical northern gold-mining region. In the course of the study five variants of settlement in the region being discussed were compared.

The first variant presented a picture of today's network of settlements. The four remaining variants called for the population to be concentrated in a smaller number of larger settlements; the degree of population concentration became greater as the variant number increased. Simultaneously with the growth of the variant number the number of communities decreased on account of the resettlement of their inhabitants in larger communities. With a growth in the variant number, however, there was an increase in the travelling radii to and from the places of employment.

The calculations determined the expenditures incurred in daily travel between the places of residence and the places of employment and in the establishment of camps for shift workers. These camps were assumed to be located at places more than 40 km distant from the permanent places of residence (40 km is the travelling radius corresponding to one hours' access by bus). In all of the calculations it was assumed that bus transportation is used for journeys of up to 40 km both to and from the places of employment and for cultural and day-to-day purposes, and that helicopters are used for journeys exceeding 40 km. In all of the variants it was assumed that the same norms obtained with respect to the provision of living space (9 m^2 per capita at permanent places of residence and 6 m^2 per capita in camps for shift workers) and that all of the housing was fully equipped with the necessary engineering services.

The studies revealed that the most efficient variant of settlement is the one which entailed the use of camps for shift workers (a 14-day shift).

This confirms the economic desirability of concentrating the population in the larger inhabited places under conditions typical of northern mining regions (see table).

Table

Comparison between variants of settlement in the region studied
(by efficiency-adjusted total expenditures, in millions of rubles)

Pattern of settlement	Variants of settlement				
	I	II	III	IV	V
Entire population residing in permanent settlements with daily intercommunity travel to and from places of employment	188	140	126	129	125
Establishment of camps for shift workers on the basis of the places of employment being more than 40 km distant from the place of permanent residence					
7-day shift	188	140	126	126	101
14-day shift	188	140	126	125	97

Even at the current level of development of transportation facilities it is economically expedient for workers employed in scattered mining enterprises to be settled in a well organized town, with maximum daily travelling radii to and from work of not more than 30 - 40 km. With further advances in transportation technology the maximum daily travelling radius could be increased without an increase in the time spent on travelling.

Furthermore, these well-organized towns could become places of permanent residence (depending on the character of the system of settlement) of large groups of employees quartered in camps for shift workers set up at remote mining enterprises (at distances of up to 100 km and more).

Thus, under northern conditions, one large well-organized town could be a permanent residence for workers employed in the mining enterprises located over vast areas. In the region we studied, the size of the population of such a town in the optimum variant was around 35,000 people. In a number of northern regions, however, especially where there is specialization in the processing of bulk-type natural resources (oil, gas, iron ores, etc.), depending on the degree of technical progress in transportation, such towns could accommodate upwards of 100,000 people.

It should be noted that in order to determine the optimum population concentration it is not enough to use only quantitative indices, since there would be no allowance for the sociological aspects of collective settlement. For example, in the larger population centres it is easier to arrange for an all-round, high-quality system of social services and amenities. The larger the population centre, the greater the possibility of providing for employment of second members of the family. An increase in the population density facilitates the formation of a more diversified sociological living environment (there is an increased flow of miscellaneous information and an improvement in its quality as well as expanded opportunities for establishing contact with a wide section of the public, which contributes to the formation of a more mature and versatile personality).

Under the harsh natural and climatic conditions of the North, the development of large well-organized towns calls for the working out of special town-planning decisions.

For a long time, most of the general plans for northern towns were worked out in conformity with universally accepted construction standards, regulations and procedural instructions, which were drawn up principally for the regions in the central zone and did not take into account the specific conditions of the North. Lately, at a number of research institutes all-round research has been carried out which has been aimed at the establishment of regional standards and regulations and also special procedural instructions for the planning and building of northern towns.

In the northern regions, owing to high cost factors (such as permafrost, low temperatures and unfavourable wind conditions) for populated centres of the same size as corresponding places in the central zone, with a similar standard of sanitary-engineering services and building density, the costs per hectare of built-up area are twice as high. This creates a need for a maximum concentration of types of urban construction (industrial, housing and utilities, transportation, etc.), in the smallest possible area and for a compact spacing of the units constituting the urban environment.

One of the most effective ways of intensifying the use of areas allocated for building is to arrange for their architectural design to be compact. This not only stems from the need to intensify their use but from efforts to create more favourable microclimatic conditions in the area to be used for housing development (to reduce the wind speed, to increase insolation by means of planning techniques which utilize brightly coloured surfaces of buildings that reflect the sun's rays, and even to increase to some extent the daytime temperatures in the interior spaces of the housing developments). At the same time a compact building system reduces the average distance from the housing development to the facilities located at the town centre.

The most important element in the design of a northern town is the town centre. When planning it, allowance must be made for certain aspects of the regional specificity of northern towns: the territorial isolation of the inhabitants of northern towns from the country's major cultural centres; the necessity to spend a greater proportion of one's time under cover, and the predominance in the population of young, more active age groups who make very heavy demands on the cultural and social welfare facilities. In conformity with these characteristics, a town centre in the North must be more developed than in the central zone of the country; its institutions must ensure that there is a more diverse range of cultural and social facilities and greater freedom of choice, both as regards occupations and forms of recreation.

The pre-eminence of the mining industry results in a large proportion of the industrial installations being located far from the town precincts

(oil and gas fields, gold fields, mines, pits, etc.). This decreases the relative importance of areas comprising the industrial zone which are situated within the town precincts, but at the same time calls for the establishment of a major transportation network in the immediate vicinity of the main built-up areas in order that workers can be transported to industrial installations situated outside the town precincts.

Constituting another characteristic of northern towns are the demands which are made upon the cultural and social services. Whereas in the central regions of the European part of the U.S.S.R. a sharply differentiated system of cultural and social services may prevail, studies carried out by a number of planning institutes have shown that in the North it is more rational to partially consolidate cultural and social facilities. Besides being better able to satisfy the needs of the population, such a consolidation makes it possible to enlarge the institutions and thus to reduce the estimated unit costs (per 1,000 inhabitants).

The character of the demographic structure of the northern population exerts an important influence on the allotted quotas of the cultural and social institutions. Thus, the fact that the proportion of preschool children is higher than the average for the U.S.S.R., necessitates making a significant increase in some areas in the number of places normally allotted in teaching institutions for children (in the Magadan Oblast, for example, it is increased by 30 to 40%). The smaller proportion of individuals of high-school age makes it possible to decrease the number of places normally allotted in grades 8 to 10 by 20 to 50%, depending on the regional conditions. The predominance of small-family units in the urban population calls for a significant expansion in the network of communal catering establishments, workshops of every sort and kind, maintenance shops, athletic institutions, clubs, motion picture threatres, libraries, etc.

Every large town, including those in the North, requires the establishment of a green belt. Because of the harsh natural and climatic conditions, the green belt of northern towns has practically no agricultural functions. At the same time, the organization of green belt recreation fulfils a special role.

When drawing up plans for the layout of green belt zones in northern towns maximum allowance must be made for the microclimatic conditions. In contrast to the southern regions of the country, here it is not recommended that coastal areas characterized by highly unfavourable microclimatic conditions (strong winds, high air humidity, fogs, low water temperatures, and a constantly shifting shoreline due to the ebb and flow of the tides) be developed as recreational zones. On the contrary, recreational zones should be located well back from the coastlines, in depressions situated to landward between low-lying hills. Highly favourable for the positioning of recreational zones are river valleys, where the active layer of the soil is thicker, the drainage is better and the arboreal vegetation is richer. Such examples of the positioning of recreational zones near northern cities exist in the environs of Magadan (the Snezhnaya Valley), Petropavlovsk-on-Kamchatka, Murmansk, and Noril'sk.

Wherever possible, the institutions using recreational zones of northern towns must make up for the deficiency of solar radiation and the unfavourable effect of the polar night on the human organism, and aid in the acclimatization of people arriving in the North from other regions of the country. It is therefore highly effective here to set up complexes of recreational establishments operating the year round and in such a way as to make maximum use of the local natural microclimatic conditions. When choosing areas for recreational complexes preference should be given to slopes with a southern exposure where the wind conditions are favourable and there are better insolation conditions.

The building of these multipurpose recreational zones must be done in such a way that they become permanent structures. In summer they can be used as camps for young people, tourist centres and rest homes, and in winter as centres for skiing and other types of winter recreation. Special attention must be paid to winter sports. March, April, and, in the arctic and subarctic zones, May also, are, climatically speaking, highly favourable months for skiing, which has become such a popular sport among the inhabitants of the North.

Both covered and open-air swimming pools must play an essential part in multipurpose green belt recreational zones. In order to prolong the

swimming season, artificial heating of the water in open-air pools is recommended, and when the natural conditions are suitable, the use of the heat contained in ground waters (such as is already done at Petropavlovsk-on-Kamchatka).

Under the harsh climatic conditions of the North, questions pertaining to the preservation and transformation of the natural surroundings of a town take on a special urgency. In view of the highly specific natural characteristics of the North, the tracts of forest surrounding a northern town are of particular importance to it. They contribute to a moderation of the climatic conditions in both the town and the green belt zone, enrich the air with oxygen, protect the town and the communications system from snowdrifts and make for better recreational opportunities for the inhabitants.

It should be noted that this factor has not always been taken into account[2]. Experience has shown that in such cases there have been appreciable losses to the economy since, even in those instances where it is possible to undertake reforestation projects, the cost of them is three to five times greater than in the districts of the central latitudes.

Urban development projects in the North are made much more complicated and expensive by the presence of permafrost. Numerous complex problems also arise in connection with the planning of towns in swamp-ridden areas. It is within the Soviet North that the world's most extensive areas of swampland are located: those of the West Siberian Lowland. The discovery and exploitation of giant oil and gas deposits have resulted in the West Siberian North being transformed into a region of first-priority development. The wide scope of town-planning activity in these regions necessitates that the swamp-ridden areas adjacent to towns be developed for construction. At the present time, up to 25 to 40% of the area constituting the new oil towns (Surgut, Urai, Nefteyugansk, Strezhevoi, Yuzhnyi Balyk, and others) is reclaimed swamp and bog land[3].

In general, it is the degree of swampiness, the type of swamps and the use to which the area is being put which governs the nature of the engineering work that must be done in order to drain it. Under northern conditions, however, all improvement projects in lowland areas where the terrain has a shallow gradient

are characterized by high capital costs. On the average, they amount to 300 rubles per hectare for an open drainage improvement system, 700 rubles per hectare for a covered drainage system, and upwards of 4,000 rubles per hectare in the case of peat removal followed by mineral soil fill[4].

With an increase in the size of the town there is a decrease in the requisite unit costs (as estimated per capita) for the preservation and transformation of the natural surroundings.

The foregoing discussion confirms the previously stated view that when planning new towns in the North it is desirable to aim at the building of comparatively large urban settlements that entail a wide travelling radius by the inhabitants to their places of employment.

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ECONOMIC EVALUATION OF METHODS OF SETTLEMENT FOR EXTRACTIVE INDUSTRIES IN THE NORTH

The attraction and, especially, stabilization of a work force in northern regions depends in large measure on the mode of settlement and facilities provided, and on the degree of comfort afforded by the housing conditions. Meanwhile, this problem has as yet been imperfectly worked out and to this day many aspects are being debated by scientific and planning organizations.

In investigating the possibilites of raising the efficiency of capital investments for accommodating each northern inhabitant, one must take into account that the economic development of northern regions is primarily connected with the development of the extractive sectors of industry. As is well known, the problem of providing community services for extractive industry towns is one of the most complex in the economics of town planning.

There exists, in our view, an erroneous opinion with respect to the method of evaluating expenditures on the development of new industrial regions, the essence of which is that inasmuch as the northern regions as a whole have very rich natural resources, any expenditures on development are paid for relatively quickly. It is impossible to agree with this, for the following reasons.

1. During the initial period of intensive development the new remotely situated regions will require very heavy capital investments which, during the first few years, will inevitably exceed their return to the economy,

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Problemy Severa, (18): 177-183, 1973.

and only later on will the outlays be recovered;

2. When calculating the net economic benefit, as determined by the difference between the aggregate economic benefit and the magnitude of the requisite costs, it is also necessary to include the costs for the establishment of social capital, i.e., housing construction and the provision of cultural and community facilities;

3. As is well known, even though the costs of community services are not a constituent part of the cost of production, they have a direct effect on the size of the capital investments required, and ultimately reflect in the economic benefit accruing from the development;

4. The traditional pattern of settlement in the form of camps or small towns presupposes the existence of an already developed integrated industrial centre, the establishment of which in northern regions is difficult to achieve.

Furthermore, the time factor must also be included in the calculation of the economic benefit, since the economic losses associated with the tying up of capital in industrial development (the interval between the time that explored deposits are ready for development and the beginning of their exploitation), amount to substantial sums of money.

The ensuing discussion of the possible methods of accommodating workers in the extractive industries will take into consideration the aforementioned factors.

In view of what has been said, it seems necessary to consider three aspects of the economic evaluation of the various methods of accommodation:

1. To ascertain and make comparisons between the level of efficiency-adjusted costs incurred in providing the totality of housing and community services in any one method of accommodation;

2. To determine the economic efficacy, with respect to the economy as a whole, of arranging for the type of settlement selected;

3. To trace and analyze the combined costs associated with the development of any one system of settlement in the development of new industrial regions.

The calculations performed have shown that all three methods do not give an unambiguous answer with respect to the economic efficacy of arranging for a housing complex, although they do make it possible to obtain an all-round and objective evaluation of it.

In order to analyze the service costs in accommodating industrial and service employees it is necessary to consider all possible methods of settlement in each specific case. The most plausible of these are as follows:

1. Build a workers' settlement of the traditional type directly at each of the deposits, where all of the staff with their families would reside permanently. Evidently, this variant is only possible in the case of major deposits and is discussed more for the sake of comparison than with a view to its realization in the immediate future;

2. Construct a new support town or expand an existing one for the purpose of accommodating the industrial staff developing a number of deposits arranged in groups in close proximity to one another. This sets up conditions favouring the integrated development of these deposits and the possibility of accommodating the industrial personnel in one centre. The entire population would reside either permanently or temporarily (by agreement) in this support town and the workers would commute daily to each of the deposits being exploited (it is assumed that the town would be situated near enough to permit daily commuting to the work sites);

3. The shift work method of developing deposits, entailing the construction of specialized bunkhouses for the accommodation of the industrial personnel and the supporting staff directly at the work sites, with all of the

workers and the members of their families residing permanently in a base town.

We have compared these variants in terms of the capital investments that would be necessary for the construction of housing and buildings for the provision of social amenities, current expenditures on the upkeep of the communities, and also the additional costs of transporting the workers to their places of employment.

Obviously, the cost structure for the accommodation of workers in each of the variants being considered will be different. Thus, in the case of the traditional method of development capital investments would be required only for the construction and operation of the settlement. The magnitude of these costs can be determined by analogy with any newly constructed urban-type settlement that has a population of between 10,000 and 15,000 and in which the breakdown of costs for construction is normally as follows: housing construction, 65 - 70%; civil engineering, 17 - 20%; provision of engineering services and transport, 10 - 18%.

The procedure which is used for determining the volume of the operating costs has been worked out by the Research Institute of Construction Economics (NIIES), Gosstroi, U.S.S.R.

In order to calculate the capital investments that would be required for the second method of settlement, i.e., for the building of a town serving as a daily supplier of workers, provision must be made for two possible variants: the establishment of a single support town, or of two towns (one of them existing, and the other in the process of being developed). This division is necessitated by the fact that in some cases the possibility exists of attracting a part of the labour reserves belonging to a town that has already become established for the purpose of exploiting new deposits located nearby.

The cost structure for the variant which calls for the building of a support town consists of the following components:

1. Capital investments required for the construction of housing and municipal buildings to accommodate the entire population associated with the

exploitation of deposits located near the town. One of the possible forms of financing is the enlistment of assets belonging to ministries and agencies through shared participation in noncentralized funds;

2. Costs incurred in setting up amenities at each of the deposits (such as cloakrooms, shower baths, drying rooms, and snack bars);

3. Expenditures on the operation of transport facilities. It seems to us that the expenditures on the construction of roads and provision of transport can be disregarded, since the proportion of these costs for municipal transportation would be negligible in comparison with the costs of industrial transport operations.

In the shift work method of development the cost structure is made up of three main components: the operating costs for the housing and municipal construction in the base town, the expenditures required for the building and operation of the shift work complex, and the costs incurred in the transportation of industrial employees.

When comparing these three variants of settlement in terms of the level of efficiency-adjusted costs, a number of circumstances must be taken into consideration: 1) the extent of capital construction must be determined in accordance with the life of the deposits (15 years for gas fields and 35 years for oil fields); 2) the population of the base towns can range from as little as 30,000 - 50,000 to upwards of 100,000 people; 3) with daily commuting, the distance from the deposit to the base town would be not more than 60 km, with intermittent commuting (the shift work system) it would range from 100 to 600 km; 4) when estimating the cost of providing community facilities it must be kept in mind that approximately half of the total number of shift workers would be absent from the base town.

The cost indices of constructing facilities for various methods of developing deposits are compared in terms of the magnitude of the efficiency-adjusted costs, included within which are all of the above enumerated types of expenditures that are typical of each variant of settlement being considered.

In order for all of the variants to be objectively comparable, unitary starting positions must be adopted. In our calculation, the numbers of industrial employees are taken to be 75 and 500 in gas fields and 500 and 2,700 in oil fields. These are the most commonly encountered indices of minimum and maximum employees developing deposits. For calculating the total size of the population, a typical family unit of 2.6 persons is assumed for the regions of Western Siberia and the North.

With the traditional method of accommodation, i.e., construction of the community directly at the deposit, capital and operating costs for housing construction, civil engineering, construction of community facilities, engineering preparation of the townsite, and the planning and provision of public services and amenities are calculated for the entire population, that is, the raison d'être* personnel, people employed in the service industries, and dependents.

In the calculations of the efficiency-adjusted costs with respect to the second method of accommodation (the support town), in addition to the above enumerated expenditures there is a group of expenditures associated with the construction of service facilities and certain service enterprises at the work site, as well as the costs involved in the transportation of the raison d'être personnel.

Finally, when arranging for the shift work method in the "pure form", also taken into consideration are costs connected with the construction of camps for shift workers, expenditures on transportation and the cost of constructing airfields.

As a result of the calculation, the efficiency-adjusted costs are obtained for all of the variants being considered when the foregoing conditions are met (Figures 1, 2).

The results make it possible to assess the degree of economic efficacy of the possible methods of accommodation.

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* "Gradoobrazuyushchii" (town-forming) is a new term meaning that segment of the population of a town for which the town is built, i.e., production personnel. It is here translated as "raison d'être" personnel. (Transl. Ed.)

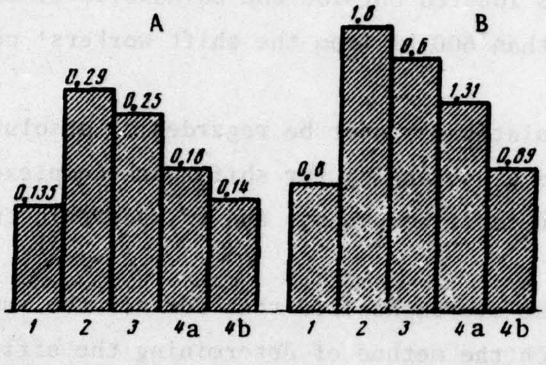

Fig. 1

Efficiency-adjusted costs for the accommodation of personnel at gas fields by various methods (in millions of rubles)

A - 75 production employees; B - 500 production employees. 1 - traditional method of development; 2 - one base town providing workers daily; 3 - two base towns providing workers daily; 4 - the shift work method: (a) base town in the zone of the gas deposits; (b) base town outside the zone of the gas deposits

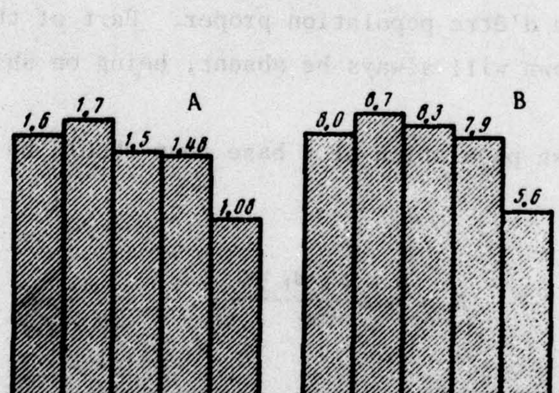

Fig. 2

Efficiency-adjusted costs for the accommodation of personnel at oil fields by various methods (in millions of rubles)

A - 500 production employees; B - 2,700 production employees. 1 - traditional method; 2 - one base town providing workers daily; 3 - two base towns providing workers daily; 4 - the shift work method of development: (a) base town in the zone of the deposits; (b) base town outside the zone of the deposits

The per capita costs of accommodation for the purpose of exploiting oil and gas deposits proved to be lowest for the shift work method of development in which the base town is located outside the boundaries of the newly developed region, but not farther than 600 km from the shift workers' camp.

These calculations cannot be regarded as absolute with respect to all possible combinations of arranging for shift work complexes. It is important to establish a list of the cost components and to ascertain their overall level.

It cannot be overemphasized that for all the importance of the economic premises on which the method of determining the efficiency-adjusted costs and total capital investments is based, it must not be regarded as the principal method in the particular case in question.

The second aspect of the economic evaluation of the different methods is ascertaining the effect of camps for shift workers on the system of settlement as a whole. Arranging for shift work complexes in conjunction with a base town or a support town has an appreciable effect on the population structure of these towns. In particular, the relationship between the raison d'être, service and dependent groups of people will differ substantially from that of a traditional town based on the raison d'être population proper. Part of the gainfully employed inhabitants of a base town will always be absent, being on shift work.

The in-town population of a base town should be determined from the formula

$$N = \frac{П + Н + П_1 + С_н}{О_{обс}},$$

where

N - the in-town population of the base town;

$П$ - the raison d'être population of the base town;

$П_1$ - the raison d'être workers in the camp for shift workers;

$Н$ - the dependents in the base town;

H_1 - the dependents of shift workers

$C_в$ - the number of shift work personnel (including employees of enterprises servicing the shift) who are off-duty in the base town, i.e., $C_в = 0{,}5\ (H_1 + O_1)$;

O_1 - the service staff of the shift work complex;

$O_{обс}$ - the percentage of the service group in the population.

Furthermore, in our view, the service employees of the shift work complex, i.e., the workers of those enterprises which are located directly at the deposits, must be included in the raison d'être group of the base town.

In the course of conducting a survey of existing camps for shift workers and by means of theoretical calculations it was established that the proportion of service employees in a shift work complex amounts to 15 - 20% of the number of industrial personnel. The larger the shift work complex, the smaller the proportion of service employees.

The entire calculated population of the base town N is determined from the formula

$$N = N + 0{,}5(H_1 + O_1).$$

Added to the in-town population is that part of the shift work personnel, the industrial and service components, which is present at the deposit throughout one shift.

The analysis of the different variants of determining the raison d'être group of the base town has shown how a particular method of calculating affects the number of service personnel. If the staff engaged in shift work (the industrial and service components) is eliminated from the raison d'être group of the town, and the families are considered to be included within the dependent group, then the percentage of service personnel will naturally decrease, and the decrease would be proportional to the percentage of the population of the shift work camp to the total population of the town. Conversely,

if the raison d'être group of the base town is increased by including the shift work personnel there would be an unwarranted increase in the size of the service group (by 1.5 - 3.0%).

In conformity with articles 2.3 and 7 in Appendix 2 of SNiP II-K. 2.62*, the population structure associated with the shift work method of production is taken to be as follows: the raison d'être group - 38% (corresponding to a family unit factor of 2.6); the service component of the population - 16%; the dependent population - 46%. With the inclusion of persons employed on shift work in the raison d'être group of the population, its share increases from 38 to 41 - 45% of the total population connected with shift work employees. Moreover, if we include not only the shift workers but all of the employees connected with the shift work system of labour, i.e., calculate the population groups as a whole for the group system of settlement, then, depending on the relationship between the raison d'être groups in the base town and in the shift work camp, the proportion represented by the service component of the population of the base town will be even greater.

The third important aspect of the economic evaluation of methods of settlement is the national economic, i.e., the benefit accruing from the integrated growth of the economy in regions of new industrial development. This evaluation is most difficult since the specific character of the formation of new regions based on the extractive industries inevitably requires a long period of time for the development of integrated high-efficiency multipurpose territorial industrial groupings.

It is the geographic location of the mineral deposits that predetermines the "focal" character of the development of industry - the developed areas will inevitably alternate with vast, sparsely inhabited areas. The dispersed pattern of development of the resources and the inadequacy of the existing transportation links greatly complicates the problem of equipping and settlement. Added to this are the difficulties of ensuring that all of the groups of able-bodied people are provided with employment.

* Construction Standards and Regulations. (Transl.)

The construction of a traditional centre of population of any size requires the integrated development of the economy in such a way that all of the able-bodied people are drawn into the productive sphere. The development of the extractive industries alone will not permit this to happen. Furthermore, provision must be made to ensure that the second generation growing up in a newly established town or settlement will be able to pursue a normal lifestyle. By way of illustration, the maximum life of a gas field is 15 - 20 years and, consequently, the centres of population that have sprung up there will rapidly cease to be of importance for urban development.

Evidently, the shift work method of accommodation will make it possible to overcome many of the aforementioned economic problems, especially during the initial period of development of new industrial regions.

In future, subject to there being a need for it, it should be relatively easy to use a housing development for shift workers as the basis for establishing a town or workers' settlement. This type of future town is exemplified by Yuzhnyi Balyk, which was planned as a shift work complex at the Mamontov deposit and subsequently became an industrial settlement, and then a town.

Thus, the foregoing economic analysis confirms the efficacy of the shift work method of accommodation during the initial period of development of new industrial regions, even when the direct capital investments are equal to the costs that would be incurred by using another method of settlement. It will make it possible to establish at the earliest possible date normal living conditions for the industrial and operating personnel, and will hasten the day when a real economic benefit is derived from using the northern resources. At the same time, shift work complexes could become the foundation stone and serve as the motivating force for the very rapid development of an infrastructure, not only with respect to isolated geographic points, but even large areas of the North.

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CAMPS FOR SHIFT WORKERS IN REGIONS OF NEW DEVELOPMENT IN THE NORTH

Occupying a special place in the working out of new systems and patterns of settlement in the northern regions are new types of towns and workers' settlements in the relatively inaccessible and remote regions of the North. Camps for shift workers constitute one of these types.

During the period 1968 - 1970 the Leningrad Zonal Research and Planning Institute for the Standardized and Experimental Design of Housing and Public Buildings (LenZNIIEP) was engaged in working out plans for specialized housing complexes for the shift workers of the oil and gas fields in the northern regions of the West Siberian Plain. It was as a result of these studies that the principles were defined which govern the setting up of camps for shift workers capable of accommodating from 50 to 3,000 people.

The studies conducted attracted great interest on the part of the main mineral extraction agencies of a number of ministries. By order of Glavtyumen'neftegaz (Ministry of the Oil Industry, U.S.S.R.), in 1971 LenZNIIEP drew up a technical plan for a camp to accommodate 1,380 shift workers employed at the Mamontov oil field in Tyumen Oblast (Figure 1). At the present time, by order of the Magadan Oblast Architectural and Building Department, LenZNIIEP is working out plans for camps to accommodate 100 and 500 shift workers employed at the mining installations of Severovostokzoloto. By order of the Ministry of the Gas Industry, U.S.S.R., plans are being worked out for camps for shift workers employed at the Sarym and Lor-Egan compressor stations and at the gas

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Problemy Severa, (18): 184-187, 1973.

collection points in the Medvezh'e gas field.

The most efficient way to erect buildings for shift workers is to make them of prefabricated or prefabricated relocatable design. Thus, in 1971, LenZNIIEP collaborated with the All-Union Institute of Light Alloys (VILS) in submitting an experimental plan for a shift workers' housing complex to accommodate 300 people. The structural solution of the plan was based on the use of aluminum panels incorporating efficient insulation (Figure 2).

At the present time, a very acute problem is to introduce the construction of experimental and individual shift workers' housing complexes. This is necessary in order to check the operational performance of the complexes and to ascertain the optimum conditions for their use.

The lack of information about the shift work method of developing remotely situated and relatively inaccessible deposits has resulted in a number of northern organizations forming erroneous concepts with respect to the specific characteristics of new types of settlements. For instance, in 1972 an order for the planning of expeditionary settlements of a seasonal type for use in Magadan Oblast (Severovostokzoloto) was given to LenZNIIEP under the heading of camps for shift workers, even though the specific character of these camps is altogether different.

It is impossible to separate the design work on types of structures from the planning of the settlements for which these types of buildings are intended. It is for this reason that the need for camps to accommodate shift workers and members of expeditions is paralleled by a need to work out plans for camps for the housing of construction and assembly workers, geologists and geophysicists, loggers and so on.

Recent scientific studies of the distinctive features and anticipated trends in town planning activities in the northern regions have demonstrated the advantage of group systems of settlement based on large and medium-sized support cities, and also on small industrial towns and settlements. These

Fig. 1

A housing complex to accommodate 1,380 shift workers employed at the Mamontov oil field in Tyumen Oblast (LenZNIIEP, 1971. Department responsible for new types of dwellings and public buildings, Chief Architect V. V. Chernykh)

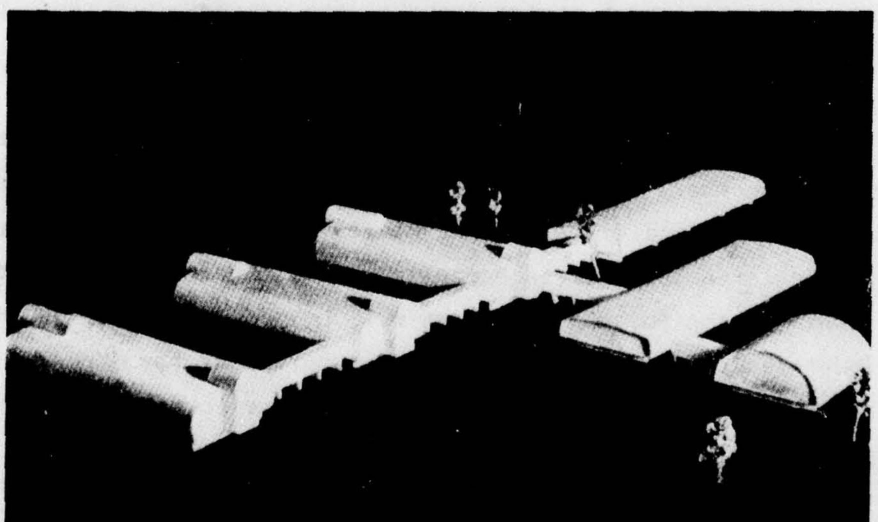

Fig. 2

An experimental housing complex made of efficient construction materials and designed to accommodate 300 shift workers (LenZNIIEP, 1972. Department responsible for new types of dwellings and public buildings, Chief Architect V. V. Chernykh)

systems must include mobile elements of settlement such as camps for shift workers, expeditionary settlements and communities dependent on shuttle-type transportation.

The necessity for bringing into production as soon as possible newly discovered northern mineral deposits, and the relative underdevelopment of these regions have set up the preconditions for using camps for shift workers in systems of settlement. Most often, new deposits exhibit a dispersed pattern, located far from one another, from already existing settlements, and from surface transportation routes. The mining enterprises at the deposits are therefore subject to the same conditions of autonomous development as are narrowly specialized industries.

The constant improvements in technology result in a shortening of the time periods required for the working out of the deposits and a decrease in the demand for production personnel. Furthermore, limited use of female labour is made at oil and gas fields. All this restricts the establishment of permanent settlements at deposits such as these and inhibits their integrated development. At the same time it necessitates the use of relocatable accommodation components, which can be brought into use within a short period of time at the next location after a deposit has been worked out.

Camps for shift workers complement the base towns. The employment of second and third members of the family, courses of instruction, the provision of cultural and welfare facilities and the health protection system, i.e., the socio-economic complex needed for each family, are assured by the development of the base town. A camp for shift workers will be merely a built-up complex at a remote industrial site. While work is in progress at the deposits it will be occupied by the regular shift of production and service personnel.

Besides the climatic and socio-economic factors hindering the growth of permanent settlements in regions of new industrial development, the North is characterized by complex soil and geological conditions (swampiness, a high content of peat, a high water table, and permafrost) which complicate the choice of the areas to be built up. Camps for shift workers and other

temporary settlements make it possible to avoid many difficulties. At the same time the provision of a system of settlements for accommodating shift workers, members of expeditions and personnel using shuttle transportation within the oil-bearing and gas-bearing provinces will facilitate the growth of the supporting urban centres.

Based on a study of experience gained in the use of camps for shift workers employed at the Messoyakh camp complex in the northern part of Krasnoyarsk Krai, some necessary corrections have been made in the structure of camps for shift workers that are presently in the planning stage. They are primarily concerned with all social and cultural services, included within which are public catering, shops, medical care, and facilities for sports and leisure.

The experience gained in the shift work organization of labour indicates that where camps for shift workers are set up there is a need for an extended working day (from 8 to 12 hours), depending on the type of job, and for working without holidays (in order to achieve maximum labour efficiency under the conditions of the shift) for a period of 7 to 15 days, followed by a long break.

The base settlement must be provided with a number of additional establishments, contributing to the efficiency of the shift work. These include facilities for preventive medicine and recreation for workers between shifts, special round-the-clock child-care establishments and boarding schools, offices responsible for home deliveries of orders for groceries and household goods, domestic services, schools and higher educational courses enabling shift work personnel to improve their qualifications between shifts.

The housing component of camps for shift workers must consist of comfortable dormitories of the hotel type. The design basis of the buildings must be conducive to their rapid assembly and dismantling, which means using prefabricated relocatable buildings with a high degree of factory finish, and making sure that the premises are in a ready state and fully equipped.

The small forms of settlement, which are uncommon in the other climatic regions of the country, call for further elaboration and design solutions.

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A SYSTEMS APPROACH TO DETERMINING THE MAIN TRENDS IN THE DEVELOPMENT AND LOCATION OF A NETWORK OF TOWNSITES IN THE NORTH

Prior to the seventies the process of settlement in the North was, for the most part, extensive rather than intensive, as was the growth in the number and sizes of the towns and other inhabited places. Today it is not the duplication of former, traditional patterns of settlement that is central to the problem of town planning, but the purposeful design of new patterns that are more efficient in terms of their social and economic effects. This calls for the adoption of a systems (programmed) approach to the determination of the main trends in the location and development of a network of townsites.

The systems approach presupposes:

1. A clear definition of the constructive objectives in arranging for settlement in the North, their systematization and an estimation of the possibilities which exist for achieving these goals in the long term;

2. The identification and study of the main problems posed by existing patterns of settlement with a view to achieving the proposed constructive tasks.

3. A prediction of the main trends in the economic development of the North and of the way in which they (and also the demands that will be made on the resources) are likely to influence the location and development of a network of townsites;

4. An assessment of the relative advantages of the main alternatives available concerning the location and development of future northern townsites;

5. The working out of comprehensive social and economic programmes

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Problemy Severa, (18): 188-195, 1973.

aimed at the realization of a General System of Settlement in the North.

Thus, the determination of the main trends in the location and development of a network of townsites in the North must be accomplished in several stages, so as to ensure that the general objectives of Soviet society are combined with the constructive purposes emanating from them which culminate in arrangements for settlement. The combining of these objectives and resources is a multiple-choice activity and it is complemented by devising comprehensive programmes to ensure that the best alternative is realized.

In order to make the location and development of a network of towns in the North more purposeful and more integrated, the future development prospects and the extent to which they correspond to predicted reserves must be worked out in greater depth. Consequently, analyses of previous trends in settlement will have hardly any impact (despite the prevailing custom) on the task of predicting the future, and will serve merely as a means of identifying the basic problems in the location and development of a network of townsites. Many of the traditional trends in the development of settlement in the North lose their importance when considered in the light of a new social and economic situation. An examination of scientific hypotheses concerning the applicability of scientific and technological development to achieve town-planning objectives has an especially important role in the North.

The use of the systems approach in order to determine the main trends in the location and development of a network of townsites is also necessitated by the fact that most of the characteristics of settlement do not lend themselves to quantitative analysis or formulization. The systems approach presupposes measurement of all of the aspects of settlement which can be quantitatively expressed, and the constructive definition of the qualitative aspects which cannot be measured.

The extent to which the objectives in arranging for settlement are achievable in the long term depends not only on town-planning solutions but

also on external factors (pertaining to settlement), the dynamics of which form the subject of independent predictions. Pre-eminent among these are advances in science and technology, the development and allocation of resources, improvements in living standards, availability of resources, demographic trends, economic aspects, and so on. At the same time, a division such as this is undoubtedly a provisional one, as the patterns of settlement in their turn have an effect on socio-economic, demographic and ecological factors, thus forming reverse links in the chain.

In the long term, it is the interaction between the social and economic factors of settlement which is the cardinal principle in working out a General System of Settlement in the North.

The constructive purposes for which a network of townsites is located and developed. The initial stage in determining the main trends in the location and development of a network of townsites must be a formulation of the constructive objectives of the prediction. The qualitative and quantitative characteristics of these objectives denote the corresponding objective standards, the achievement of which can be assured by the various alternatives that are available for the location and development of a network of townsites.

The need for a constructive formulation of the objectives in locating and developing a network of townsites in the North arises from:

1. The increasingly important role of integrated, area-wide arrangements for settlement and production in raising the efficiency of resource development and intensifying economic growth (this includes the increasing significance of social and town-planning criteria as applied to the development and allocation of resources);

2. The growth in the demands of the population for employment, comfortable living conditions, leisure, information (education and culture), social contact, health care and physical training, a favourable environment, etc.

These are the prerequisites that have resulted in the determination of a system of constructive objectives in the location and development of a network of townsites. The method used here was the "tree of objectives", which

ensures matching correlations and hierarchical arrangement of the objectives of settlement and production.

The general objective is the achievement of a logical spatial system of northern development.

The first-level objectives are:

1. Formulating town-planning prerequisites for the development and allocation of resources.

2. Establishing town-planning conditions for maximum accessibility of material and social goods and services.

Objective No. 1 - Formulating town-planning prerequisites for the development and allocation of resources in the North. This includes the following second-level objectives:

1.1. Establishing town-planning conditions for the formation of area-wide industrial complexes involving the extensive development of intra-industrial ties with enterprises located in the inhabited region of the U.S.S.R.

1.2. Establishing town-planning conditions to guarantee production by labour resources, decrease labour mobility and provide opportunities for professional training and advancement.

1.3. Establishing town-planning prerequisites for shortening the time span required for the building and commissioning of new enterprises.

1.4. Establishing town-planning conditions for the concentration of industry (taking into account the need for preserving the state of the environment).

1.5. Establishing town-planning prerequisites for full employment of the able-bodied population.

1.6. Establishing town-planning conditions for the development of an industrial infrastructure.

<u>Objective No. 2</u> - Establishing town-planning conditions which are necessary for the inhabitants of the North to have maximum access to material and social goods and services, which includes the following second-level objectives:

2.1. Establishing town-planning conditions to enhance the social well-being of the urban and rural population.

2.2. Establishing town-planning conditions to provide the urban and rural population with an adequate selection of places of employment.

2.3. Establishing town-planning conditions to provide the urban and rural population with an adequate selection of cultural entertainment.

2.4. Establishing town-planning conditions to provide the urban and rural population with places for recreation (including weekend recreation).

2.5. Establishing town-planning conditions to provide the urban and rural population with a variety of opportunities for social contact.

2.6. Establishing town-planning conditions to improve the quality of the environment.

2.7. Establishing town-planning prerequisites to increase the degree of uniformity in urban and rural settlement.

2.8. Establishing town-planning prerequisites to shorten the spans and to reduce the cost of urban construction.

The identification of a third level in "the tree of town-planning objectives" is inadvisable, since alternative versions of programmes ensuring that the objectives are achieved may arise here. For example, an enhancement in social well-being can be achieved either by developing a network of autonomous services or through a network of intersettlement services.

In the course of determining the main trends in the location and development of a network of townsites "the tree of town-planning objectives" must be drawn up in detail, which entails establishing objective standards in the form of quantitative indices, threshold values ("not more than", or "not less than") or clear qualitative definitions. An example is given in the table.

Table

Approximate requirements (standard levels) when arranging for settlement (as applied to the conditions in the Soviet North)

Description of requirements	Threshold indices	Optimum indices
Time spent on travelling to work (one way)	90 min	Up to 30 min
Time spent on regular social and recreational travel	120 min	Up to 40 min
Time spent on off-duty travel to places of recreation and on day trips	150 min	Up to 60 min
Time spent on day-to-day travel (on foot)	20 min	10 - 15 min
Degree of environmental pollution	Within the prescribed norms	Insignificant pollution
Built-up area per 1,000 inhabitants	5 - 10 ha, depending on the size of the town	8 ha, depending on the size of the town
Sizes of the urban settlements		
a) Base cities	Not less than 50,000 and not more than 250,000 people	75,000 to 150,000 inhabitants
b) Other towns	Not more than 50,000 people	5,000 to 10,000 inhabitants in the zones of influence of base centres, not less than 10,000 outside these zones
Sizes of the rural settlements	Not less than 1,000 people	1,000 to 2,000 people, depending on local conditions

<u>Contemporary problems in the location and development of a network of townsites</u>. Essentially, the problem of locating and developing a network of townsites in the North amounts to ascertaining the discrepancy between the desired and the actual result when arranging for settlement. The desired result is described by a group of objectives, the actual result by their contemporary parameters, reflecting the extent to which these objectives have been achieved.

In this connection, the essence of contemporary problems of settlement in the North lies in the need for achieving a significant increase in the social, economic and ecological efficiency characterizing the location and development of a network of townsites, with maximum allowance made for the specific character of the North (the harsh natural conditions, the low population density, the remoteness from the main inhabited region, the transient nature of the population, the peculiarities of its social and demographic structure, and the complications which arise when setting up a base for the supply of construction materials).

The main problem encountered in the location and development of a network of townsites in the North is a consequence of the fact that the existing pattern of small settlements runs counter to current trends in industrial development and to the requirements of the population.

An analysis of settlement during the period 1960 - 1970 has shown that the basic mechanisms governing the distribution of the population growth in the North are similar to those for the U.S.S.R. as a whole: more than 70% of the absolute growth of the urban population is accounted for by cities of more than 100,000 inhabitants. At the same time, the number of townsites is for the most part increasing at the expense of the small urban settlements. In attracting three quarters of the increase in the urban population, the number of large cities in the North has risen by only 6%.

Of the more than 100 urban settlements that have developed in the North, more than 90% are small, poorly equipped communities. As a result, the average size of one urban settlement in the North has even declined by 8% over

the past decade. The scattered pattern of small settlements in the North is the cardinal factor accounting for the poor quality of the urban environment, which is in turn associated with a number of socio-economic problems such as the high mobility of labour and the irrational age and sex structure of the population. In a number of the settlements the extent to which the population is provided with well arranged housing is considerably below the average for the country as a whole.

The pattern of small settlements is also the reason for the poorly developed transportation infrastructure in the North.

The intensification of industry, and the increase in its scope and complexity are stepping up the demand for professional training and education of the workers. Qualified workers are more fastidious with respect to standards of housing and social amenities in general.

It is therefore necessary to overcome the disparity between the growing demands of the urban and rural population of the northern regions for material and intangible goods and services, on the one hand, and for a spacious and well ordered arrangement of places in which to work, live and relax, on the other.

<u>The effect of scientific and technological advance in the development of natural resources on the location and development of a network of townsites.</u> Industrial growth in the North, at least during the next ten years, will continue to be channelled in the direction of resource development, thereby predetermining the overall character of a network of townsites in which small and medium-sized towns and settlements will predominate. The intensification of the economy and the effect of the scientific and technological revolution will impart new characteristics to the industrial development of natural resources, characteristics that will influence the location and development of a network of townsites. We shall enumerate some of these.

The most important of these industrial changes is the transition to a qualitatively new technological framework for the development of natural

resources, including all-round mechanization and a growth in the proportion of automated processes. A "northern" technology will be in evidence everywhere. As a result, the number of workers associated with the development of mineral resources will at first have to be stabilized and, later on, decreased.

The second important industrial factor which will have a significant effect on settlement (the industrialization of building) will make it possible to shorten the time spans required for the development of mineral deposits and to alter the ratio between the numbers of construction workers and extraction personnel in that there will be a decrease in the first group. This will tend to stabilize the numbers of inhabitants in the towns and, at the same time, limit their growth. The next important economic mechanism is the increasing tendency for territorial industrial complexes or centres of production to become established as fixed capital accumulates. As a result, there will be a strengthening of the base for construction of support centres in the form of large cities serving to facilitate the development of the North, as well as an increase in the sizes of these cities.

In the North, the influence of social trends on settlement is becoming stronger. The improvement in material well-being and the rise in the educational and cultural levels of the population are enhancing its social mobility, thus pointing the way to an urban environment provided with a high standard of social amenities and a sufficiently varied range of employment opportunities. The availability of a choice in the type and location of employment, and in the opportunities for education, cultural pursuits and recreation has become the most important social criterion in arranging for settlement. As a result, the population is displaying an increasing desire to move closer to the major industrial centres, which results in the expanding processes of inter- and intraregional migration.

The preference of the population for an urban environment with developed social and cultural facilities and offering a varied range of employment opportunities is coming into conflict with the existing pattern of small settlements, and also with the limited opportunities for the development of major urban centres in the North. The retention of workers

in northern regions will only become possible when a social infrastructure has been created and when there is a sufficiently wide range of employment opportunities. Unless these conditions are met there will inevitably be an intensification of the migration from the North into regions characterized by better climatic conditions and higher standards of urbanization. The social trends are therefore promoting a rising degree of interdependence and the integration of inhabited places in systems of settlement. The increase in the scale and duration of its development will lead to an expansion of the transportation infrastructure of the North, thus reinforcing communications between the populated places and also with the major support centres of the inhabited region of the country. At the same time, the incompleteness of the scientific and technological cycle of development of the various types of transport, and also the capital intensiveness of the transportation facilities are lessening the opportunities for establishing close interrelationships between the townsites in the North, as compared with the regions of the inhabited zone.

The constantly increasing role of scientific and technological advance in the development of industry and settlement therefore demands that a distinction be drawn between its workable and hypothetical aspects. The various patterns of settlement must be based on practicable scientific and technological innovations which have already been fully or partly realized or, at least, have passed through the stage of experimental verification and have demonstrated their economic efficiency. Advances envisaged for the distant future, for example, new high-speed and cross-country types of transport, should only be taken into consideration as a means of increasing the flexibility of the alternatives being compared and of the theoretical guidelines for the future.

The overall analysis of social and economic trends thus points to the need for formulating sufficiently flexible settlement alternatives which take into account both the purposeful orientation and the resource limitations affecting the solution of problems of locating and developing a network of townsites in the North.

<u>The effectiveness of the various alternatives for locating and developing a network of townsites</u>. The central undertaking in the systems approach is to make a qualitative and quantitative comparison of the effectiveness of the main alternatives for the location and development of a network of townsites in the base regions.

The process of selecting the best of these alternatives is in many respects determined by how fully the cost and benefit components are reflected in each variant. Consequently, it is important to distinguish clearly all of the components connected with the realization of any one alternative, i.e., all of the components in the process leading to changes in the network of townsites.

The following model of a three-dimensional evaluation is used as the criterion in the choice of the alternative:

$$\text{Choice} = \frac{\text{Effectiveness} \times \text{feasibility}}{\text{Costs}}$$

This criterion expresses the choice of the alternative by reference to the upper limit of achievement of the constructive purposes per resource unit, having regard to the feasibility (probability) of the alternative in question.

The following main alternatives are considered in scientific studies and development practice in the North: large base centres, small cities, camps for shift workers supported by towns, camps for expedition members supported by major centres, and systems of group settlement in which small communities predominate.

Currently predominating is a correlation of alternatives "in schematic plan", without considering time objectives and potentialities, making it impossible to ascertain their real socio-economic effectiveness and expediency.

The following factors constitute the starting point in the choice of the best alternative:

1. The requirements in the immediate future - first and foremost, the need to solve the problem of improving the existing pattern of settlement with the object of keeping the workers from moving away and thus eliminating the irrational mobility of the work force;

2. Industrial trends, stimulating, on the one hand, a growth in the basis for the development of base centres in the form of large cities, and restricting, on the other, the scale of the developmental basis for the remainder of the townsites in the North;

3. The expansion of social needs and also the rising demands with respect to the quality of the urban environment, which is creating a need for fundamentally new variants of settlement;

4. The gradual provision of the economic potentialities for meeting these needs, in conformity with the stages in scientific and technological advance and the development of the North.

Thus, the optimum alternative in locating and developing a network of townsites in the North must satisfy both current and anticipated requirements, and take into account both contemporary and future patterns of technology, as well as the change in the economic potentialities. This presupposes an obligation to consider the proposed alternatives in relation to time, and imparts a special significance to the criterion of their flexibility and elasticity.

These requirements can be considered methodically by switching to a phased comparison of the alternatives when the specific time periods within which the corresponding selection criteria predominate are identified.

The duration of each of these stages can be taken to be from 15 to 20 years, which corresponds to the length of the investment cycle embracing the working out of scientific and technological designs, their introduction, and the transition to qualitatively new technological configurations in developing the North.

The distinctive character of the immediate future consists in increasing the scale of development of the natural resources of the North and using for the most part modernized standard equipment. Only at the end of this period can one expect to see an abundance of fundamentally new vehicles and machinery especially designed for the North. Moreover, emphasis must be placed on the need for solving first of all problems pertaining to the existing pattern of settlement in the North, i.e., improving the quality of the urban environment in order to maintain a permanent supply of workers. It is from these standpoints that it is advisable to discuss the existing alternatives for settlement.

One is immediately struck by the noncompetitiveness of the planning variant which calls for the formation of group systems of settlement in the North relying on possible scientific and technological advances in transportation, since new types of transport in the North, even if their economic expediency is substantiated, will obviously not make their appearance until much later on.

It might also be well to point out that, as indicated by economic calculations, it is inadvisable to aim at the formation of group systems of settlement in the North based on already operational types of rapid transport, since the provision of these types of transport, even in moderate quantities, will necessitate substantial additional expenditures.

The economic factor also emerges as the principal cause of the noncompetitiveness, at least in the stage corresponding to the next two decades, of the shift work alternative of settlement. Essentially what happens in this system of settlement is a duplication of housing construction operations - in the base town and in the corresponding camp for the shift workers. Furthermore, the provision of transportation arteries in order to link the base town with the camp will necessitate substantial capital investments.

The variant which calls for the formation of large towns throughout is unacceptable because it conflicts with the character of production in the mineral extraction industries.

The shortcomings of the expeditionary pattern of settlement are similar to those indicated for the group systems of settlement.

During the next decade the only superior alternative from the social standpoint (as compared with existing patterns of settlement), which at the same time conforms to the economic potentialities of the stage comprising the long-term plan for the development of the economy, is the establishment of small towns with populations of 5,000 to 10,000 inhabitants and more. At the same time, it is advisable to continue with the formation of large regional base centres in the North, along with relocatable camp complexes at deposits with a limited lifetime.

The three patterns of settlement which have been identified - regional centres, small well-equipped towns, and relocatable camps - may prove to be a sufficiently reliable basis for the development of settlement in the North during the next 15 to 20 years. The transition to their planned formation will denote a systematic intensification of the trend towards population concentration in the North, which will make it possible to raise the standard of services and amenities. The building up of well-equipped, habitable small towns in the North can be done efficiently by assembling prefabricated units brought in from the construction supply bases located in the major northern centres and from the inhabited zone adjacent to the North.

The establishment of well-equipped small towns provides an answer to the rising social and everyday needs of the population and at the same time makes it possible to depend on an operational rather than a hypothetical transportation infrastructure. A distinct improvement in the transportation network in the North, which is the *sine qua non* for improving settlement, is within the range of existing economic potentialities.

After the long-term plan for the development of the economy has been realized, a new, temporary stage will set in, the economic potentialities of which will make it possible to reconsider the choice of the best alternative for settlement and to aim at patterns of settlement which will be more worth-while in terms of the social and cultural opportunities they offer.

This may mean adopting the group alternative for settlement which was rejected in the preceding stage. It will make it possible to unify the small towns that had previously been established into a single town-planning system characterized by a much wider range of employment opportunities and other social advantages.

During this stage more auspicious opportunities will also open up for establishing camps for shift workers and for members of expeditions.

Thus, the most reliable and effective pattern of settlement for the North is one that will be increasingly wide-ranging with time and also sufficiently flexible, taking into account both the requirements and the economic potentialities of the present stage, and also the need to aim at patterns of settlement which will ensure that there will be a rich social environment in the future.

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V. EXPERIENCE ABROAD

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THE STUDY, PROTECTION, AND UTILIZATION OF THE NATURAL ENVIRONMENT IN ALASKA AND THE CANADIAN NORTH

Experience of other countries in the development of their northern regions confirms the exceptional importance of the formulation and study of problems to do with the protection and rational exploitation of the natural environment in the North. The scale of development of the North outside the Soviet Union is still small, especially in its chief regions, namely, Alaska and the Canadian North. It will suffice to say that only 350,000 people live in an area of about 6,000,000 km^2 in the territory of the Canadian North. Already, however, direct and indirect traces of disturbance of the natural systems of the North by human economic and other activities are beginning to appear. The considerable broadening of the scale of development of the northern regions planned in the future is attracting the attention of the scientific and administrative organs of these countries to the problems of the natural environment of the North and is stimulating them to extend their ecological researches and also to define and take the necessary measures for the rational exploitation of nature.

These considerations make a critical study of the experience of other countries and, in particular, the U.S.A. and Canada, very useful: with Canada, of course, the Soviet Union has concluded an agreement (in 1971) on scientific and technical cooperation, including development of the North; with the U.S.A. an agreement has been signed (in 1972) on collaboration in the study

Problemy Severa, (18): 196-212, 1973.

and protection of the natural environment, and one of the points of this agreement relates to the North. Soviet and American scientists link the necessity for the study of arctic and subarctic ecological systems not only with the development of the North, but also with the special importance of the polar regions for predicting the world ecological situation and global changes in the climate of our planet[5,6].

It must also be remembered, however, that the conditions for putting into effect scientific and practical decisions taken in the field of protection of the environment are substantially different in socialist and capitalist societies; in the U.S.S.R., where the contradictions between State and private interests, so characteristic of the U.S.A. and Canada, are absent, opportunities for the rational utilization of natural resources are incomparably broader.

Taking Alaska and the Canadian North as examples, let us examine those most characteristic properties of the tundra and treed tundra ecosystems that determine their instability and delicacy of balance, and make the arctic natural environment so particularly susceptible to anthropogenic disturbance.

The dominant factor in the existence of the natural systems of the North is heat. The deficient inflow of solar radiation and the low intensity of daylight in winter retard their development. In Alaska and in Northern Canada, the territory of which lies in the zones of the arctic deserts, tundra, treed tundra and northern taiga, the annual radiation balance ranges between zero and 20 - 25 kcal/km.

In the cold period of the year, anticyclonic weather conditions associated with dominance of the polar and North-American anticyclones, predominate. In the direction from the Pacific and Atlantic seaboards into the interior of the continent the climate becomes increasingly continental in character and the mean minimum air temperatures fall from -14°C to between -30 and -34°C in inland districts of Alaska and Northern Canada, where some regions are found with mean annual air temperature minima of -50°C. The great dryness of the

air facilitates intensive radiation cooling of the surface and the formation of powerful atmospheric inversions, where the dense, cold lower layer of air prevents free mixing of the air masses. When the temperature falls to -40°C a thick ground-level fog is frequently formed and persists in the windless frosty weather in the intermontane depressions. When nuclei of condensation are present, freezing fog also develops. Under these conditions atmospheric pollution may have particularly dangerous consequences. Waste products of combustion, discharged into the atmosphere from factories, automobile transport, thermal power stations, and the industrial burning of oil and gas, are not carried into the upper layers of the atmosphere but gradually accumulate to give dangerous concentrations immediately above the town, settlement, or factory.

Where the level of evaporation is low (not more than 10 - 20% of the quantity of atmospheric precipitation), despite the low annual precipitation (from 100 to 500 mm) the tundra and treed tundra are characterized by extensive waterlogged terrain. In Canada, waterlogged ground occupies up to 10,000,000 hectares, a scale that is comparable with the waterlogged districts of Western Siberia. On the broad expanses of the Arctic Lowlands in Alaska and the morainal and glacial-lake plains of Northern Canada with their very flat surface, the runoff of the rivers is very slow. Because of the prolonged ice cover and the low intensity of mixing of the water layers, rivers of the North are poor in oxygen and microorganisms responsible for self-purification processes. Accordingly, improperly purified effluents from ore-concentrating plants, oil spills, and domestic sewage may pollute arctic rivers over long distances and poison all forms of life. With the low water temperatures and the limited ground-water intake the pollutants persist for a long time, and after the summer high water, especially where the hydrographic network is so highly branched as it is in Northern Canada and Alaska, traces of pollutants and their effect on hydrobionts can be found at a considerable distance from the industrial sources.

The universal distribution of perennially frozen ground has a great effect on the instability of the ecology of the North. The zones of continuous permafrost distribution include the whole of Northern Alaska to the

north of Brooks Range and also Northern Canada to the west of Hudson Bay: the Laurentian Plateau and the adjacent lowlands, and the whole of the Canadian Arctic Archipelago. Regions of discontinuous permafrost reach the latitude of the 0°C mean annual isotherm, and cover the whole territory of the Labrador Peninsula as well as Central and Southeastern Alaska. Only the southwest coast of Alaska and the Aleutian Islands, because of the influence of the warm Alaskan current, are free from permafrost.

Local differences of relief, lithology, and drainage have a definite effect on the character and distribution of frozen ground. Frozen ground is either absent or lies at some depth below the surface under lakes and ponds more than 2.5 m deep and more than 600 m wide in Alaska and Northern Canada. In the zone of continuous permafrost, effects are also observed on the size and character of occurrence of large water masses. In the valleys of the Yukon, Tanana, and Kuskokwin rivers, (Alaska), close to Great Bear Lake, and the Mackenzie River (Canada) permafrost is found to a depth of less than 1 m, and on the lower terraces it is sometimes absent. The greatest thickness of permafrost (more than 500 m) is found on the islands of the Canadian Arctic Archipelago: Ellesmere, Baffin, and Victoria islands. On the mainland of the North American continent, the deepest permafrost is found on the Arctic Lowlands of Alaska, where it reaches 300 m or more almost everywhere, with the maximum thickness (396 m) on Point Barrow. The mean thickness of the perennially frozen ground in the rest of Alaska and continental Canada varies between 40 and 100 m.

The presence of perennially frozen ground in the waste mantle determines the highly dynamic behaviour of the ground above the permafrost. This is due primarily to seasonal changes in the active layer. In intermediate seasons the tundra surface is most vulnerable and exhibits such cryogenic phenomena as thermokarst and solifluction. Mechanical disturbance of the surface caused by the movement of tracked and wheeled vehicles leads to the development of gully erosion. According to American figures, the rate of growth of gullies from heavy vehicles may amount to 3 - 7 m per annum. As a result of disturbance of the surface, the underground ice thaws more deeply and this increases the

waterlogging of the soil. As a result, earth and snow-and-ice roads usable one season are completely unusable the following year (Figures 1 and 2).

Under conditions of low temperatures and a short growing period, herbaceous and mossy-lichenous vegetation is widespread. As the climate becomes more continental in character, thickets of dwarf birch, willow, rhododendron, and other shrubs appear. Along the valleys of the Yukon, Colville, and Mackenzie rivers black and white spruce and balsam poplar extend far to the north in the form of galleried forests. Despite the high degree of adaptation of the tundra and treed tundra flora to the harsh environmental conditions, any disturbances of the plant cover as a result of economic development of the territory are ruinous. This is due primarily to the comparatively simplified structure of northern ecosystems with their easily broken chains of interconnections.

Processes of soil formation in the Arctic and Subarctic take place very slowly. American investigations have shown that in the north of Alaska several thousands of years would be required for natural decomposition of the vegetation and the formation of a layer of peat about 1 m thick. On disturbed territories, especially if the thin soil cover is destroyed, self-renewal of the plant cover is therefore virtually impossible. It even takes 5 years for the vehicle ruts in the wet localities of the Arctic to become overgrown, and more than 20 years in dry districts. The intense waterlogging restricts building operations in these areas. Territories most suitable for building are most commonly upland watersheds. Islands of woody vegetation are also found in these places. Felling the trees and inadequate replanting of seeds leads to the development of treeless tundra landscapes of anthropogenic origin, and these are much less productive.

Given the high sensitivity of northern ecosystems to human activity, traces of disturbance of the natural associations become noticeable even if this activity is on a comparatively small scale. As yet these disturbances are not universal, but only focal in character, occurring wherever the high-grade deposits of minerals are exploited. In the opinion of some western

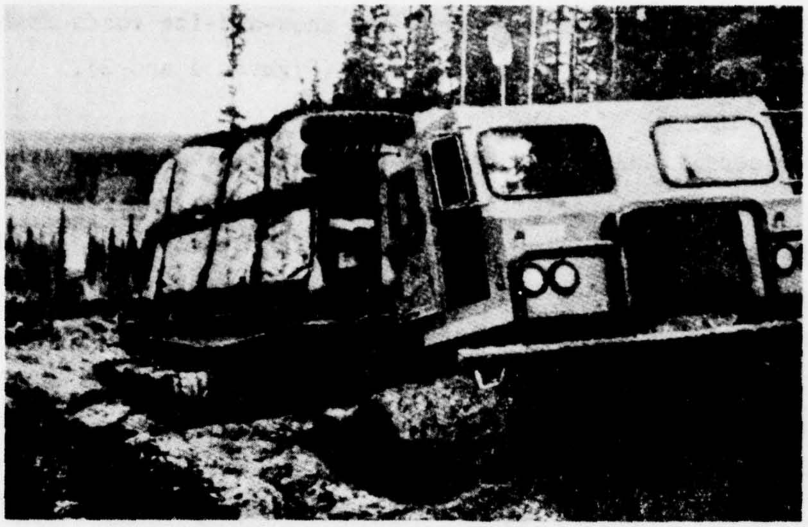

Fig. 1

Nodwell heavy-duty all-terrain vehicle, capable of negotiating snow and bog, in the treed tundra ("North", 1972, Vol. 20, No. 3)

scientists, however, even episodic human activity of an expeditionary nature has already disturbed the natural equilibrium to some extent over a large part of the North. For instance, Dr. Tom Cade, Director of the Laboratory of Ornithology of Cornell University (U.S.A.), has said of extensive areas of northeastern Alaska to the east of the Colville River, that it is almost impossible to find an area of land measuring more than 100 square miles (260 km^2), including the "Arctic Wildlife Range" nursery, where some unjustifiable effect of human activity is not already in evidence[28].

In the Canadian North and, in particular, in Alaska, the system of protected areas is widely developed.* In Alaska this is largely associated with the old-established policy of "conservation" of natural resources, caused by the conflict between the interests of major monopolies from the southern U.S.A. and, more recently, between groups of the upspringing local bourgeoisie, each of whom attempts to hold on to reserves of natural wealth for the future. This policy also reflects contradictions between the interests of the Federal

* The author is undoubtedly including in his definition the National Wildlife Ranges, National Wildlife Refuges, Wilderness Parks and National Parks in Alaska, and in Canada the Game and Bird Sanctuaries and National Parks. (Transl. Ed.)

Fig. 2

Gullies formed along the route followed by heavy-duty all-terrain vehicles ("North", 1972, Vol. 20, No. 3)

Government and the State Administration[1,2,3].

The increasing attention to the subject of preserves is due at the present time to the attempt to preserve the relatively unstudied natural life of the North for scientific research and also as a major recreational resource of the country. The territory of national parks, wildlife preserves, and other protected areas in 1971 accounted for 11% of the total area of the State, i.e., 16,500,000 ha. About 17 preserves have been organized on these lands, including the "Arctic National Wildlife Range", "Clarence Rhode National Wildlife Range", "Nunivak National Wildlife Refuge", "Cape Newenham National Wildlife Refuge", "Kenai National Moose Range", "Kodiak National Wildlife Refuge", etc., the "McKinley National Park", seven parks of local importance, wilderness parks, and also "National Forests", in the southeast of the State, the "Naval Petroleum Reserve No. 4" in the north, and other specially protected lands.

In January, 1972 the State Administration obtained the right to acquire a further 32,000,000 ha of land so that in the next five years it could create national parks, preserves, and other protected areas on them and protect them against economic exploitation. Naturalists picked out 35 territories to be included in the system of national parks and protected lands of Alaska. These included districts of almost untouched wilderness in the Wrangell Mountains, the Brooks and Alaska ranges, areas of the delta of the Copper and Yukon rivers and the valleys of the Tanana, Kuskokwim, and Porcupine rivers, several areas on the Alaskan Peninsula and certain islands (Barren, Unga, and Shumalin) in the south of Alaska, and other territories[19].

The large Wood Buffalo National Park in the south of the Northwest Territories and in the north of the province of Alberta has existed for a long time in Northern Canada. In 1972 three new national parks were created: Kluane (Yukon Territory), Nahanni (Northwest Territories), and Baffin Island. The question of organizing a reserve to the east of Great Slave Lake, covering an area of 141,000 ha, is under discussion. Also, in the Yukon and Northwest Territories, 14 wilderness areas have been allocated as places where strictly protected animals (wild caribou, bison and, in particular, birds) can gather[16].

In 1971 a law on what are called "ecological reserves" was passed in Canada.* Reserves are created for general scientific research and diagnostic and educational purposes; ecological reserves, so far as can be judged from the literature, are intended chiefly for the preservation and study of strictly definite ecosystems that are of the greatest interest. In Canadian scientific circles, the creation of ecological reserves is considered to be particularly promising in the North, where vast crown reserves of unstudied lands are located.

One of the most serious problems for the natural environment of the American North, in the opinion of American and Canadian scientists, is that of the preservation and restoration of the plant cover of the tundra and treed tundra. The study of this problem pursues the following aims: maintenance of the stability of the hydrothermal regime of permanently frozen ground and its protection from deep thawing and increased waterlogging; ensuring food reserves for herds of caribou; preservation of territories valuable for recreation and sanctuaries.

Meanwhile, with the upsurge of industrial activity in the American North there has been an increase in the incidence of forest fires, after which full recovery of the plant cover will be achieved only after 100 - 120 years. In Northern Canada in the period from 1956 to 1965, fires were observed annually over an average area of more than 158,000 ha; 80% of the fires broke out in arctic and subarctic regions[21]. These fires greatly reduce the pasture resources of the treed tundra and northern taiga. In 1971 a special symposium on "Fires in the boreal zone" was held in Fairbanks, Alaska. Particular attention was paid to the effect of fires on the vegetation and the animal world of the Arctic. Fires causing impoverishment of the caribou pastures were one of the main causes of the catastrophic decline in the caribou population in the Canadian North from 670,000 head in 1949 to 200,000 at the beginning of the 1960s. Some improvement in the situation has taken place only recently: aerial photography in 1967 showed that the population of the herds had increased to almost 390,000 animals.

* It would appear that the author is referring to the 1970 amendment to the Territorial Lands Act and the 1971 Land Use Regulations. (Transl. Ed.)

Considerable disturbances of the plant cover and surface of the tundra are also caused by traffic movement, especially in the early period of development of the territory, when right of ways are selected for future roads, pipelines, electric power transmission and communication lines, sites for bases, camps, and warehouses. The territory between "Naval Petroleum Reserve No. 4" and the "Arctic National Wildlife Range - North Slope of Alaska" has become a place for concentrated human activity. The tracks made by tracked vehicles 10 - 30 years ago during seismic prospecting still remain. Now almost the entire territory to the north of Brooks Range has been severely eroded by the wheels and tracks of tractors and all-terrain vehicles, tractor trains, and heavy bulldozers. Even when thermokarst and erosion of the surface are not observed as a result of vehicular traffic, as a rule the vegetation is damaged and crushed. As a result there is often a natural replacement of the lichens by sedge associations, as has frequently been observed in the oil regions of Northern Alaska[24]. As a result of this change of vegetation the reserves of winter food for the 300,000 caribou of the arctic littoral plain have been reduced.

In 1969 the local and federal governments in Alaska prohibited the use of tracked transport in the tundra during the summer. At the present time research to overcome this problem is being pursued in three main directions: first, the development of special means of transport for the tundra designed to cause minimum damage to the easily degraded surface - vehicles moving on an air cushion, all-terrain vehicles with smooth tracks, wheeled vehicles with a very low tire pressure, and so on (Figure 3); second, the isolation of means of transport from the surface of the tundra by means of mats made of synthetic materials (their use has already begun in Northern Alaska); and, third, the development of various methods aimed at rapidly restoring the disturbed surface (discontinuation of economic use of the disturbed areas, sowing quick-growing grasses, etc.).

With the increase in number and size of settlements in the North the problem arises of recycling or disposal of industrial and domestic liquid and solid waste. Experiments to study the possibility of natural processing of domestic waste at low environmental temperatures carried out at the town attached to the Eielson Air Force Base (near Fairbanks) have confirmed the

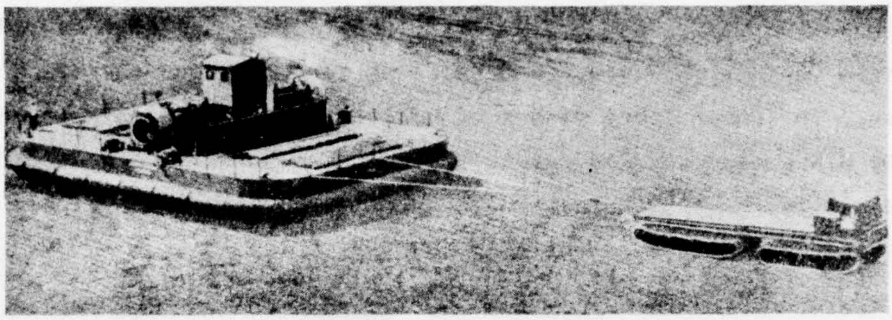

Fig. 3

Field trials of an air-cushion vessel, capable of carrying a load of 250 tons, in Canada in the summer of 1972 ("North", 1972, Vol. 20, No. 3)

ineffectiveness of this method[26]. The problem of waste disposal in the Arctic is now regarded as so serious that some scientists have raised the question of restricting growth of the population of settlements in these areas[30]. Different engineering solutions to the problem have also been suggested: chemical purification of sewage, the burning of garbage at high temperatures, deep burial, collection and transportation of refuse to permafrost-free areas. Intense air pollution is found above the towns of the Subarctic lying in mountain valleys with unfavourable meteorological conditions, such as Fairbanks (Alaska) and Whitehorse, Yellowknife, and Inuvik (Canada). Investigation of the causes of atmospheric pollution by the "Cold Regions Research and Engineering Laboratory" of the Arctic Institute of North America (Point Barrow, Alaska) has shown that with a combination of low temperatures (below -35°C) and atmospheric inversions, the presence of even a small number of sources of pollution leads to the formation of a particularly dangerous type of atmospheric pollution - "freezing smog". Its thickness above the town may reach 20 - 30 m, and visibility is reduced to 10 m. In the winter months - from November to the end of March - the degree of atmospheric pollution above Fairbanks, where not more than 45,000 people live, is on a level with Los Angeles, with a population of over 1,000,000, and for atmospheric lead concentration the town heads the list of cities of North America[14].

The development of persistent atmospheric inversions, aggravating pollution of the air basin, is not characteristic of a considerable part of Northern Canada. However, other no less harmful phenomena are observed in those areas. In summer large masses of polluted air from highly urbanized regions of the U.S.A. are carried far to the north. The study of photographs taken from satellites has shown that in the period of intensive cyclonic activity atmospheric pollution extends as far as Hudson Bay.

Tests of atomic and hydrogen bombs carried out above ground in the postwar years and the subsequent underground tests that still continue in the U.S.A. and Canada* have led to radioactive contamination of the northern zone. Investigations by scientists from the U.S.A. and Canada have shown that the northern regions accumulate radioactive substances particularly easily. They accumulate in plants, in the animals that consume these plants, and in man who uses animal meat for food. The most active assimilators of radioactive substances (strontium-90) are lichens. Investigations to determine the degree of radioactive contamination of several areas of Arctic North America have shown that the content of radioactive deposits per kilogram dry weight is 250 - 260 μ Ci in wild grasses, 190 in birch, 4,900 in lichems of the species *Cladonia alpestris*, and 10,000 in the lichen *Nephroma arcticum*. Analyses of caribou meat and bones have shown that the concentration of strontium-90 is at the maximum allowable level for man, whereas that of caesium-137 is at twice this level (50 μ Ci). By 1961 the content of strontium-90 in the bone tissues of the indigenous population of Alaska, living off caribou meat, was 12 times higher than in the immigrant population. Testing 5-megaton hydrogen bombs at a depth of 1,800 m on Amchitka Island (Alaska) in November, 1971 led to the death of about 1,000 - 1,100 sea otters, hundreds of birds, and thousands of fishes.

The problem of degradation of the natural environment of the North has been rendered particularly acute because of the development of the oil and gas industry in the north of Canada and in Alaska. Commercial exploitation of oil and gas is at present mainly centred on deposits in the region of Cook Inlet and Kenai Peninsula (Alaska), where up to 11,000,000 tons

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* Sic. (Transl. Ed.)

of oil is produced per annum, Rainbow Zama in the north of the province of Alberta (Canada), yielding 6 - 8 million tons, and Norman Wells on the Mackenzie River (Canada), with an annual production of between 100,000 and 150,000 tons.

All these industries were established a comparatively long time ago and, so far as can be judged from the literature, as the result of strict administrative control in these regions environmental disturbances have been minimized. For instance, close to the oil wells on Kenai Peninsula contamination of the area with oil is absent and no disturbance of the ecological conditions of hydrobionts has been observed in the rivers and lakes[20].

Considerable concern has been aroused by contamination of the coastal waters of Cook Inlet and the Pacific Coast of the U.S.A. and Canada along which giant tankers sail with Alaskan oil. According to calculations made by American specialists, every day along the sea lane from Southern Alaska to the Western U.S.A. one-thousandth part of the oil transported pollutes the coastal waters. There is the problem of contamination of these waters during drilling and exploitation of off-shore wells. Of the 111,000,000 tons of oil produced in 1970 in Southern Alaska, more than 8,000,000 tons were obtained from deposits in the off-shore zone of Cook Inlet[17].

Oil pollution, extremely toxic in general, and distinguished by its high persistence, is particularly dangerous in northern waters. The low water temperatures prevent the decomposition of oil films. About 100 species of bacteria, yeasts, and fungi can oxidize hydrocarbons. Optimum conditions for their activity are created when the water temperature is +24, +30°C, or above. Self-purification from oil pollution takes many months. Naphthene acids, present in oil and its products, are particularly toxic. In a concentration of 0.3 mg/litre they are lethal for hydrobionts. In 1971, research was carried out in Canada to study the effect of unpurified oil on certain species of algae. These experiments showed that the contaminating substances preserve their toxicity even after 2 months under arctic summer conditions.

The deterioration of the quality of sea water through oil pollution

has its effects on birds, fish (especially Salmonidae), crabs, and other valuable species of commercial importance to the sea-fishing industry. In northern waters oil pollution is concentrated in a narrow ice-free strip of coastal waters and it is a threat to all wildlife.

Besides pollution of sea waters, pollution of the atmosphere has also become very noticeable in the region of the oil industry. Only part of the gas obtained as a by-product of oil production is utilized. For example, in 1970 6,120 million m^3 of natural gas was produced from the deposits of Southern Alaska, of which only 1,550 million m^3 was used on the surface (for burning as fuel, for liquefaction, and for ammonia and carbamide manufacture), 2,047 million m^3 was pumped back into the formation to maintain the pressure, and 1,050 million m^3 was burned in flares. In July, 1972 the flaring of this natural gas was prohibited at the Alaskan oil wells, even to the extent of prohibiting the exploitation of the wells if the gas cannot be utilized[17].

For the reasons indicated above, the combustion of hydrocarbons contaminates the atmosphere in the North particularly rapidly. Lichens are very sensitive to atmospheric pollution. It is actually possible to tell if the air contains an increased concentration of hydrogen sulphide and sulphur dioxide from the depressed appearance of lichens.

In the course of development and exploitation of the rich oil and gas deposits of the Far North of Alaska and Canada, the total production of oil and gas will increase considerably, and so also will the effects of industrial activity on the natural environment. In the north of Alaska, by 1985 it is planned to produce from 100 to 200 million tons of oil (according to different predicted levels). The construction of a Trans-Alaska Pipeline from Prudhoe Bay to Valdez on the south coast of Alaska, from which the oil will be shipped by tankers to the Pacific coast, is awaited. In the Canadian North, in the basin and, in particular, in the lower reaches of the Mackenzie River, and on the islands of the Canadian Arctic Archipelago (Melville, Ellef Ringnes, and Baffin Islands) active and fairly successful prospecting for oil and gas is in progress. Plans for the construction of oil pipelines along the Mackenzie River

to the south and also gas pipelines from the north of Alaska through Canadian territory into the southern regions of Canada and into the U.S.A., are being prepared. The expansion of oil and gas production is anticipated in the southern regions of the Canadian North. The construction of a highway along the Mackenzie River has already begun[3,4,9].

In connection with the prospective extensive development of the oil industry in the American North, calculations have been made to predict possible effects on the environment. Once the Trans-Alaska Pipeline comes into operation, which is expected to be not before the end of 1974 or the beginning of 1975, between 270,000 and 330,000 tons of oil will be pumped through it daily (i.e., 90 - 110 million tons of oil per annum), and this oil will be shipped to the south by tankers with a dead weight of 160,000 tons (20 tankers a week) from Prince William Sound. Losses of oil on loading are estimated to be around 19,000 tons per annum, and during transshipment 316 tons daily. Permissible leakage of oil along the route of the pipeline is estimated to be not more than 9,000 tons per annum. In addition, the volume of discharged water from the tanker ballast is between 47,700 and 173,800 tons daily. Oil-cleansing equipment for this water is to be carried on board the tankers, which will reduce the oil concentration in the tanker ballast to the ratio of 1:10,000. Shore installations will reduce this ratio further to 1:100,000. However, even with this degree of purification, 1.9 tons of oil will enter the water of Prince William Sound daily. However, in the spring and autumn enormous numbers of water birds congregate in the delta of the Copper River close to Valdez, the future oil port: ducks and about 10,000 Canada geese. Almost half of the nesting population of Alaskan swans is also concentrated in the same place.

On account of the ordinary operations of loading tankers with oil, fishing for salmon and other valuable sea products will evidently have to be discontinued because of contamination by hydrocarbons and by the raising of the temperature of the coastal waters. Investigations have shown that the most sensitive hydrobionts to petroleum products of all kinds are the eggs and young of fishes[22].

Bristol Bay and adjoining territories are also under the threat of oil pollution. This region, from geological observations, is regarded as a very promising source of oil and gas, and seismic prospecting in the shelf and littoral zone has been in progress for several years. In 1969 the region of Bristol Bay was included in the list of lands with national priority as the most valuable wildlife reserve territory. Here, in particular, large nesting places of many water birds are concentrated. Later, in May 1970, attempts were made in Alaska to introduce local legislation to prevent the exploitation of minerals in the Bay or, at least, in its inner part, a salmon habitat. However, the suggestion was overruled by the State authorities, evidently not without pressure from the oil companies.

Many ecological problems are connected with the impending construction of the Trans-Alaska Pipeline. The following causes and consequences of the main disturbances of the natural equilibrium by exploitation of this pipeline have been noted. The stability of the pipes may be upset (the southern half of the pipeline runs through zones of major faults and through seismically active regions, where in the last 70 years 23 earthquakes of 6 points or more on the Richter scale have occurred), and this will cause spilling of oil. The pipeline is an obstacle to seasonal migrations of wild animals, mainly caribou.

To study the effect of a construction of this vast length on the migration of caribou, in the winter of 1971 a snow embankment 3 km long, covered with sacking, was built to simulate the pipeline. Observations showed that some caribou will use specially provided underground or overground crossing places to get through the embankment, whereas others, the majority of the caribou, were unable to cross the barrier. Other experiments specially carried out in Alaska have also demonstrated similar behaviour on the part of animals faced with artificial barriers[24].

Because of the high initial temperature of the oil (+60 to +80°C) and the complex geocryological conditions, the problem of preserving the temperature conditions of the perennially frozen strata has become particularly acute in Alaska. Experimental tests conducted by the U.S. Geological Service

have provided data for the calculation of soil thawing. In the case of soil of average silt content, a pipe 1,220 mm in diameter will thaw permafrost to a depth of about 8 m in one year and down to 15 m in 20 years. Lateral thawing at the base of the pipe is 4.5 m on each side in one year, and about 9.15 m over a period of 20 years[15].

Several different methods have been advocated in order to overcome this difficulty. Better heat-insulating coverings for the pipes than those used previously are being developed with the use of plastic tape and polyurethane foam. For a large part of the route the pipes will be laid underground, but in permafrost areas with a high ice content they will rest on piles and berms.

The Trans-Alaska Oil Pipeline has to cross more than 130 water-courses, and this could lead to disturbances of their hydrological regimes, to overflowing of their banks, and to silting up of the rivers.

Huge quantities of gravel are needed as the basic insulation material for building camps, roads, airstrips and other engineering constructions required for the pipeline and also for the oil fields. Calculations by American workers indicate that to prepare the ground for an oil well from 23,000 to 43,000 m^3 of gravel is required, and to build the Trans-Alaska Pipeline, which will be laid mainly in trenches, about 13.7 million m^3 will be needed. Intensive excavation of gravel from river beds and on the coast of Northern Alaska is accelerating erosion of the seashore, it is disturbing the structure of the river and sea beds, and altering the hydrological regimes of the rivers, causing them to silt up. Admittedly, in the engineering plans for the oil pipeline that have been published, measures are envisaged for preventing undesirable ecological consequences. Special attention is being paid to ensuring accident-free operation of the pipeline and protection of the plant and animal world. Special apparatus capable of detecting leaks of even a few litres of oil is being developed. Every so often, at short intervals, a torpedo-shaped device, equipped with electronic instruments for recording deviations from the normal regime, as well as breaks in the pipes, will be passed along the pipeline. Should leaks or other serious disturbances of the conditions be discovered, the use of electronic

devices ensures automatic stopping of oil pumping within 15 - 30 sec[23].

Plans for the development of the American North are not confined to the development of the oil and gas-producing industry. In the next 10 to 15 years many new centres of mining and the timber industry can be expected to appear, with the associated construction of highways and railroads. The programme for development of the treed tundra and the northern taiga zone of Canada (the so-called Mid-Canada Corridor) in the next 20 years is also interesting[3,4,7,13].

Ecological research and the development of measures to protect the environment have been pursued on a very large scale in the last 2 to 3 years in Alaska and the Canadian North. They are designed mainly not for current, but for future needs. The fact that the study of problems concerned with the rational use of resources and lands is being pursued well ahead of their introduction into exploitation is itself noteworthy. Ecological investigations have become one of the stages in the preparation of a territory for economic development.

Some of the most fundamental systematic investigations of this type are those of the tundra ecosystems that form part of the "International Biological Programme". They were started simultaneously in Canada and the United States in the summer of 1970.

The problems chosen for study by the North Alaskan group of scientists cover a wide range of subjects:

1. The development of concepts on the functional features of wet arctic ecosystems using experimental plots in Barrow as examples;

2. The collection of the necessary field data on different types of ecosystems of cold regions for the purpose of simulation and comparison with similar systems in other countries;

3. Broadening the knowledge of the environment with the aim of solving problems concerned with the restoration of degraded taiga-tundra ecosystems susceptible to changes in the temperature regime.

The study of the effect of crude oil on the biota of the tundra has assumed an important place in the investigation of ecosystems. In this connection experimental plots have been selected in the region of Prudhoe Bay close to the oil deposits, and also in the region of Cape Simpson, where natural seepages of oil have been found. With the aid of these plots the character of the long-term effects of oil on the ecosystems of coastal tundras can be studied.

Other aspects of the research programme of the North-Alaskan group of the "International Biological Programme" are also directly connected with the expected construction and operation of the Trans-Alaska Oil Pipeline: analysis of quantitative indices of natural components (biological productivity, solar radiation, albedo, etc.) of terrains pertaining to arctic, subarctic and boreal ecosystems in succession from north to south, along the route of the pipeline. These investigations are being carried out in order to discover the so-called bioenvironmental or bioclimatic gradients. In their methodology they are close to thematic mapping, for they envisage the creation of a series of special maps and a comparative analysis of soils, the plant and animal worlds, the dynamics of the snow cover, and geocryological phenomena in disturbed and undisturbed areas of the arctic, subarctic and boreal environment of Alaska.

The first experimental studies to be made of the action of oil spills on the surface of the tundra are of considerable interest. The preliminary results themselves show that oxidation and decomposition of hydrocarbons take place very slowly, in the course of the growing period the aboveground part of plants under the oil film becomes completely necrotic; hydrocarbons penetrate most deeply into the soil in dry areas (in wet places the surface water evidently prevents deeper penetration of the oil). It is also important to note that disturbances of the soil and vegetation under the oil film are evidently caused by the oil itself, and not by changes in the temperature regime of the soils. This is confirmed by temperature measurements: the oil

film itself absorbs the sun's heat strongly and protects the soil and vegetation against heating[27].

These various investigations into the ecology of the tundra have required combining the efforts of engineers from the Cold Regions Research and Engineering Laboratory at Point Barrow (Alaska) and specialist scientists in different fields: geomorphologists, permafrost scientists, botanists, ecologists, and petroleum scientists from the Universities of California, Montana, and Alaska (U.S.A.) and Alberta (Canada), and the Center for Environmental and Human Problems in Hartford, Connecticut (U.S.A.).

Altogether the U.S. Department of the Interior has already spent $9 million and the Alyeska Pipeline Service $35 million on ecological research into the effects of the Alaska Pipeline on the environment. The preliminary results of these investigations into all problems concerning the effects of the pipeline on the environment are contained in the nine volumes of the report presented by a number of research groups to the U.S. Department of the Interior.

According to the data for mid-1972, of the total expenditure of $3 billion on construction of the pipeline, one-sixth, i.e., $500 million, is designated for the provision of measures for preventing oil leaks and also on measures connected with the restoration of disturbed terrain and the protection of the natural environment as a whole[23].

The Canadian group of research scientists working on the International Biological Programme has also paid great attention to the study of problems connected with the effects of oil pollution and the whole process of construction of planned trunk pipelines along the Mackenzie River on the natural environment. These investigations have been included in a programme for the study of the rational use of Arctic lands to be spread over several years. The first stage of this programme was completed in 1970. A general ecological assessment of renewable natural resources has been drawn up for the whole territory of the Canadian North, the locations of standard types of

ecosystems have been determined, a programme for their study outlined, and areas for future reserves marked out. This stage of the project was completed on the basis of existing published data. In this summer seasons field work has been carried out on Devon, Ellesmere and Baffin islands and on some of the polygons in the Mackenzie River Valley. In particular, problems besetting the recultivation of terrain disturbed by extractive industries, through the effects of modes of transportation on the plant cover, and the heat-dissipating effect of a large-diameter pipeline have been studied.

Industrial groups also participate in ecological research. The "Gas Arctic North-West Project Study Group" consortium, formed jointly in June 1972 by 12 American and four Canadian companies to build a pipeline across Canada with a length of 4,320 km, is carrying out the following experiment. In Inuvik (at the mouth of the Mackenzie River), near Prudhoe Bay, and in Norman Wells experimental sections of pipeline have been built in the form of a loop and a rectangle (pipes 1,200 mm in diameter) at a cost of about $2 million. The pipes are filled with oil obtained from northern Alaska or with hot air, so that the experimental situation closely resembles the conditions of actual operation of oil and gas pipelines. The tests will continue for one year. During this time data on electrical conductivity, heat flux, humidity and density of the ground, displacement of the permafrost zone, and the temperature regime of the berm above the pipeline will be obtained.

Meanwhile the most effective methods of utilization of transportation systems in the tundra regions of Canada are being studied. These methods must ensure minimum disturbance of the soil and plant cover. It is recognized that this can be done to some extent by limiting summer movement of vehicles, for it is then that heat-induced settlement and soil erosion are most widespread. It is recommended that right of ways for roads, drilling sites, and airstrips be chosen in the summer, when locations with coarse soil structure can be found and, consequently, the soil is less vulnerable to mechanical disturbance. When the route is chosen for vehicular traffic it is best to keep to low-lying areas, for the water-saturated soil profiles there are frozen through to a lesser degree, and the predominant sedge formations recover more quickly.

American engineers and ecologists have put forward new solutions to problems of protecting the natural environment in the region of the oil industry. When the first sites are drilled in the Prudhoe Bay field with an area of 88,000 ha, where the soil is highly waterlogged and deeply frozen, it is proposed to sink the wells 30 m apart, placing the rigs on a gravel pad 250 m long and 30 m wide. In that way, in the opinion of the American specialists, six wells can be drilled from one pad to cover a territory of 1,530 ha. The drilling equipment can be moved along the gravel pad without the need to dismantle it or to remove the covering. In this way the amount of movement of heavy equipment over the unstable surface of the tundra can be reduced to a minimum[11].

The possibility of restoring the disturbed soil and plant cover has been studied. Investigations have shown that the most effective method is by artificial sowing with grasses which will restore the soil conditions. If the surface is covered with soil and is undisturbed during the period required for the plants to become established, revegetation is relatively uncomplicated. An important condition for the renewal of the plant cover is the use of fertilizers. According to minimum calculations, 1 ha requires about 60 to 100 kg of nitrogen, phosphate, and potassium fertilizers[18]. Local species of grasses are the first to become established on disturbed areas of the tundra surface, and for that reason American and Canadian scientists give preference to them when choosing the sowing mixtures.*

Many expedition teams working during the summer season in 1969-1972, and also the planning and prospecting groups of industrial firms have considerably increased the volume of information on the natural environment of the North in recent years. Since the need for such factual information and generalized material on the North is increasing continually, it has become necessary to consider the creation of scientific information centres for the

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* Mixtures of seeds of small grasses have proved themselves under Alaskan conditions: a) Arcata red fescue, Nugget bluegrass, Polar brome grass; b) Manhar smooth brome, Durar hard fescue. In Inuvik a good grass cover has been obtained in disturbed test plots by sowing Kentucky bluegrass and Creeping red fescue.

natural environment. This problem is now being discussed at the University of Alaska in Fairbanks, by the National Research Council, and in the Territorial Research Council* (for the study of the Yukon Territory and Northwest Territories) in Canada.

Problems to do with the natural environment in the North and the effect of industrial activity on it are dealt with administratively by the Ministry for Indian and Northern Affairs in Canada, and the recently-created (1971) departments for protection of the environment in Alaska and in Canada. Their field of activity includes control over the operations of industrial firms in the North and the establishment of norms and instructions on a wide range of matters to do with the use of natural resources. The activity of these organizations has been reflected in the drawing up of legislation on protection of the environment of the North, which has been passed by the governments of both countries. In August 1970 guidelines for the construction and operation of pipelines in the North were published in Canada. They provide for the compulsory appointment of an environmental adviser to all industrial groups carrying out field research and planning pipelines in the North. A system of fines, sufficiently severe, has been worked out for damage caused to living and nonliving nature by industrial operations.

With the increasing demands of the government for the protection of the quality of the natural environment under the conditions of the rapidly developing oil and gas industry in the United States and, primarily, in Alaska, the American Petroleum Institute has set up a committee on ecological problems based on the long-existing environmental sector. The committee includes representatives from 21 oil companies. The terms of reference of the committee are to put forward recommendations by oil and gas companies for regulations to deal with water and atmospheric pollution, the detoxication and disposal of solid waste, the protection of areas of land, and the protection of fish stocks and of game lands.

Aspects of protection of the environment and the fundamentals of the use of natural resources have been reflected in an important document

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* The Northwest Territories Science Advisory Board under the chairmanship of Dr. O.M. Solandt was formed in 1976. The concept was developed in the late sixties and early seventies, and it was originally called the Science Council. There is no similar board for the Yukon. (Transl. Ed.)

produced by the Canadian government. This is the "Territorial Lands Act", which became law on 15 November 1971.* All the provisions of this law are contained in three major subdivisions. The first subdivision contains general rules for land usage in the Northwest Territories and Yukon Territory, dealing primarily with the order of conduct of mining operations, the crossing of watercourses, the utilization of transport routes, the organization of building or other expedition camps, conditions for the storage of fuel, and measures for the cleansing of the area from lubricating materials after mining and building operations. The second section includes the basic requirements to be satisfied when land is used and the procedure to be followed for obtaining permission for exploiting mineral resources. The permits stipulate the seasons when particular operations can be carried out, the types of machines and vehicles that can be used, methods of carrying out operations, and general measures for the protection of the flora and fauna and the water and salt regime of rivers and lakes. Particular attention is paid to industrial operations in the vicinity of reservations. If industrial firms do not carry out the obligations specified in the permit, administrative inspectors specially appointed for protection of the environment have the right to stop the operations completely or in part. Questions of making good the damage, fines, or cancellation of the permit to exploit the rented lands are dealt with in the third part of the "Territorial Lands Act".

Very similar in nature to this document in content is the proposal, now under discussion, for a law on the preservation of mineral resources during mining operations in the State of Alaska. According to these proposals, prospecting, road building, the extraction of useful minerals, and travel in State lands other than along roads are under the control of the "United States Fish and Wildlife Service", the "Bureau of Sport Fisheries and Wildlife", and directly of the United States Department of the Interior, and also of a new organ - the Alaska Department for Protection of the Environment.

In northern regions and, in particular, in Alaska, laws on the protection of the natural environment are in operation and apply to the country as a whole. An interesting law from this point of view is that on water quality

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* See footnote on p. 347. The Territorial Lands Act replaced the Dominion Lands Act in 1950 and was amended in 1970. (Transl. Ed.)

passed in the United States in 1965. In December 1970 a special system of measures was introduced to combat water pollution by industrial effluents. The norms for the discharge of effluents into rivers and lakes are determined by calculating the total ability of the river or other body of water to receive the effluents without becoming polluted. Since rivers in the North have much less capacity of this sort than rivers in the central and southern regions, the passing of legislation on water quality and the differential approach envisaged by new American laws when calculating norms for the discharge of effluents are of particular importance for northern regions. All firms whose factories are sources of possible water pollution must provide full details of their effluents and of measures taken for their purification.*

Two legislative acts were passed in Canada in 1970 in order to protect northern waters: an "Act Respecting Inland Water Resources in the Yukon Territory and Northwest Territories", and the "Arctic Waters Pollution Prevention Act". According to the second of these acts, not only persons directly guilty of polluting sea water with oil, but also persons who do not report known facts of pollution to the authorities or who do not cooperate with the government inspector for environmental protection are punished by fines. In 1971 an additional law on the protection of Arctic inland waters was passed, according to which the discharge of unpurified sewage is punishable by fines (to cover the total cost of its purification).

The effectiveness of all these governmental and public measures is difficult to foresee. In northern regions the contradiction between the

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* The firms must provide the following information: 1) the daily discharge of effluent; 2) colour of the water; 3) acidity; 4) the content of chemical products in the effluents; 5) the temperature drops of the water; 6) the content of toxic substances and fecal effluents; 7) the quantity and frequency of discharge or of dumping; 8) the type and quantity of solid refuse; 9) the characteristics of existing purification plant, and methods of supervision of the quality and quantity of the effluents. Deliberate falsification of information is regarded as an offence and is punishable by a fine of up to $100,000 or by imprisonment for up to 5 years.

increasing demands for the rational exploitation of natural resources and protection of the biosphere resulting from the rapid development of resources and the scientific and technical revolution, on the one hand, and the opportunities of meeting these demands under capitalist conditions, on the other hand, hold just the same as in the more established regions of the United States and Canada[8].

The Canadian Department of the Environment, mentioned above, has become deeply involved in a wide range of problems concerned with the natural environment in the North. Besides research into the effect of the development of the oil and gas industry and pipeline construction on the environment, the Department is engaged on the study of renewable resources of the continental shelf, it is carrying out research aimed at restoring the productivity of forests in regions of the northern taiga in the east of Canada, and it is also preparing plans on environmental impact for territories near to James Bay (Hudson Bay) and the valleys of the Nelson and Churchill rivers, areas of mining activity and major hydroelectric power construction schemes, etc.

Problems of environmental protection form an important part of the activity of several administrative organizations concerned with problems of the North as a whole. An example is the interdepartmental "Working Group on the Petroleum Industry in the North" in Canada, which includes not only higher officials of various ministries and other organizations, but also the Deputy Minister for the Environment. Ecological problems have occupied an important place in the recommendations of this working group[25]. Equal priority has been given to these problems in the basic principles of development of the Canadian North in the 10-year period 1970-1980, elaborated by the Ministry for Indian and Northern Affairs[16].

Evidence of the wide scale of research into problems of the ecology of the northern regions of the U.S.A. and Canada is given by the large number of conferences held in the last three or four years. For instance, an international conference on the productivity of northern ecosystems, their structure, and the organization of the protection of nature in polar countries was held in Edmonton

(Canada) in 1969. Later, in 1970, the Arctic Institute of North America held a conference in Rensselaerville (N. Y., U.S.A.) mainly to discuss ways of preserving ecological systems in the process of economic development and settlement of Alaska and the Canadian North. Annual scientific conferences on Alaska from 1969 to 1972 have mainly been devoted to changes in the natural environment due to the development of the oil industry in the State. The same problems, as they apply to the Canadian Arctic, with an assessment of the natural resources of the North, were the main items discussed at a symposium in Ottawa in 1970.

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THE USE OF THE ARCTIC BASIN BY THE ATOMIC SUBMARINE FLEET (FROM DATA FOR THE U.S.A.)

The first attempt by a foreigner to navigate beneath the ice was made in the summer of 1931 by the American scientist H. Wilkins in the submarine O-12, which was subsequently renamed "Nautilus". The attempt failed - the ice cutters proved to be incapable of sawing through the ice and the ship lost its rudder. They only managed to submerge the bow beneath the ice and move along it[(10)].

During World War II occasional voyages beneath the ice were made by German submarines, and in 1947-1948, by American submarines.

During the past ten years American seamen have completed a number of surface and subsurface voyages with the object of ascertaining the feasibility of using the Northwest Passage.

Following the discovery of important reserves of oil and gas in northern Alaska and on the Canadian Arctic islands the Americans completed two experimental voyages through the Northwest Passage in 1969 and 1970, using the supertanker "Manhattan". This vessel, which has a displacement of 115,000 tons, was especially refitted for navigating in ice. The cost of the work was $40 million. During the first voyage, in September 1969, the tanker, accompanied by two icebreakers, failed to pass through McClure Strait, where it sustained serious damage in the form of a hole measuring several meters in diameter.* After freeing itself with difficulty from the pack ice in McClure Strait (through the use of explosives) the tanker managed to reach the Beaufort Sea by way of

* The hole was not sustained in McClure Strait, but in the Beaufort Sea. Similarly, the tanker was freed by the Canadian icebreaker "MacDonald", and not by explosives. (Transl. Ed.)

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Prince of Wales Strait. The journey through the Beaufort Sea to the Prudhoe area (Alaska) was without incident. The tanker also succeeded in completing the return voyage from Alaska to the east coast of the United States.

Thus, with the assistance of two icebreakers and at a favourable time of the year the "Manhattan" succeeded in negotiating the Northwest Passage, the voyage in each direction taking 14 and 16 days, respectively. This achievement, however, did not demonstrate the feasibility of year-round navigation. In McClure Strait the "Manhattan" encountered ice 12 m thick. According to the U.S. Navy, in the Beaufort Sea and McClure Strait the undersurface of the ice is very uneven. Some of the ice shelves reach a depth of 50 m. On the average, the ocean depth on the route followed by the tanker is 450 to 550 m, although in the vicinity of the North Magnetic Pole it decreases to 110 m.

Based on the experience derived from the voyages of the "Manhattan" a table[13] was compiled which shows the potential speeds of a tanker in various sections of the Northwest Passage, by months (Table I).

It will be seen from Table I that in winter the ships travel slowly. Navigation at this time of the year is unprofitable.

Specialists at the Humble Oil and Refining Company, which had previously intended to transport Alaskan oil by surface tankers along the Northwest Passage, have concluded that the exporting of oil by surface vessels is technically feasible, but economically unprofitable.

American specialists, however, believe that atomically-powered submarine freighters, navigating beneath the ice, could easily negotiate the Northwest Passage at any time of the year. The ocean depths make it possible to do this (minimum depth 110 m). The distance covered when navigating below ice decreases markedly (Table II).

Table I

Potential speeds of surface vessels navigating the Northwest Passage, by months (miles/hour)

Section of route	Distance in miles	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Beaufort Sea	500	5	5	2	2	2	2	15	15	15	15	5	5
Prince of Wales Strait	250	5	5	5	5	5	5	15	15	15	8	8	8
Viscount Melville Sound . . .	250	3	3	3	3	3	3	10	10	10	3	3	3
Area eastwards of Viscount Melville Sound to Cape Liverpool	400	8	8	8	8	5	5	15	15	15	15	15	8
Along the Greenland coast . .	1,035	10	10	10	10	10	10	10	10	10	10	10	10

Table II

Distances in miles from Prudhoe Bay (Alaska) to the east coast of the United States and to European ports along various ocean routes[12]

Destinations	Under-ice route via the North-west Passage	Via Bering Strait	Via the Panama Canal	Via the Northeast Passage
London	4,385	-	11,355	5,405
Hamburg	4,405	-	11,645	5,280
New York	3,880	-	8,750	7,945
Yokohama	-	3,290	-	-

In 1960 the U.S. submarine "Seadragon" transited the Northwest Passage beneath the ice. Also, in late January 1960 the U.S. Atomic submarine "Sargo" successfully transited Bering Strait. The submarine has been given a special assignment - to study the possibility of navigating in winter in the shallow regions of the Arctic.

It was on the "Sargo" that the problem of entering and exiting the Arctic Ocean beneath the ice of the shallow Chukchi Sea was worked out. During the period January to March 1960 the atomic submarine covered a distance of 6,003 miles beneath the ice in 41 days and 4 hours, and surfaced 20 times. Sixteen of these surfacings were from beneath young ice measuring from 10 to 122 cm in thickness.

The atomic submarine "Seadragon" navigated beneath the ice in Parry Sound and beneath the icebergs of the Baffin Sea. It made three to six passages below each iceberg, one of which was submerged by more than 91 m. Another atomic submarine, the "Skate", succeeded in entering the Arctic Basin via the Kennedy and Robeson channels between Greenland and Ellesmere Island.

The Central Arctic Basin is the shortest and most useful deep-water under-ice route between the European and Far-Eastern regions. Here, the

passage into the deep areas of the Arctic Ocean is accomplished through the channel consisting of the Barents-Kara Shelf, the Nansen Basin and Hakkel Range, the Makarov Basin, the Mendeleev Range leading into the Canadian Basin, with an exit into the Beaufort Sea and southern part of the Chukchi Sea. The under-ice route subsequently passes into Bering Strait.

Between February and May in certain small areas in the Chukchi Sea, the Beaufort Sea and Bering Strait the passage of atomically-powered submarine freighters can be effected by using powerful icebreakers. In recent years, Canadian specialists have designed a new plow-type of icebreaking bow, which breaks up the ice from below. In the wake of this type of icebreaker is a strip of ice-free water which makes it possible for a convoy of ships to follow smoothly in its wake. According to the Canadian specialists' calculations, an Arctic icebreaker with a displacement of about 33,000 to 36,000 tons and a capacity of 120,000 hp will be able to reach any point in the Canadian Arctic Archipelago [14].

<u>The technology of under-ice navigation</u>. Transcontinental under-ice Arctic voyages began to be made in the fifties when atomically-powered engines made their advent in submarines.*

The U.S. Navy's first atomic submarine, the "Nautilus", which was launched in 1955, had a turbine capacity of 15,000 hp. During the first two years or so it travelled more than 60,000 miles without taking on additional atomic fuel. Its average speed was 20 knots. For more than half of the voyage the ship travelled in the submerged position; this included the journey through the Arctic Basin. The parameters of the vessel were: length, 91.5 m; width, 8.5 m; displacement, 3,180 tons; submergence depth, 230 m; daily fuel expenditure, 80 grams [8].

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* In 1966 Soviet atomic submarines made the first round-the-world voyage without surfacing. The vessels passed through various geographical zones, which included under-ice passage in the high latitudes. The machinery worked flawlessly, and the expedition was a complete success.

Purification of the air in atomically-powered vessels is done in compartments: removal of toxic gases and harmful admixtures is effected chemically and the air to be breathed is renewed by regeneration. Today, therefore, the length of time that a ship can remain underwater is determined not by the oxygen supply, but by man's physical endurance.

The navigation system used by atomic submarines when operating in high latitudes has now been fully worked out. This system ensures the determination and preservation of the direction of the plane of the true meridian, as well as the stabilization of the direction of the vertical, determination of the submarine's true speed vector, high-precision automated plotting of the path traversed by the submarine in the Arctic latitudes, periodical correction of the navigational system's operations, and illumination of the under-ice conditions[(2)].

Of special importance are the technical facilities for obtaining information about the ice conditions. The captain of a ship proceeding beneath Arctic pack ice must at all times know the thickness of the ice sheet and the configuration of its lower side, as well as the depth beneath the keel.

Hydroacoustic and television-equipped navigational instruments make it possible for the ship to detect leads of open water (polynya) and areas of thin ice (in order to break through it), safe "berthing" to the under surface of the ice and the detection of obstacles along the submarine's path (icebergs, ice hummocks on shoals (stamukhi), other ice hummocks, and sharp elevations of the bottom).

Besides being fitted with television equipment and hydrolocation, echo-sounding and ice-measuring instruments, the American atomic submarines are also furnished with inertial systems, computers and radio navigation receivers, as well as receivers for detecting signals from navigational earth satellites. In order to receive the latter, and also the signals from the radio navigation systems, the ships use extensible buoy-type antennas.

The television equipment on the atomic submarine "Seadragon", which negotiated the Northwest Passage beneath the pack ice in 1960, provided a clear image of the underwater ice formations over a distance of up to 120 miles when faint moonlight penetrated the ice to a depth of 1.2 m. The television gear was installed in the bow section of the deck and was remotely controlled, both in the altitudinal and azimuthal planes.

The ship's instrumentation, when it was submerged and proceeding at a speed of 14 knots near the west coast of Greenland in the vicinity of a large concentration of icebergs, made it possible to detect them promptly and steer away from them.

Recently, the Litton navigational system, which is suitable for use in atomic submarines, has been developed in the U.S.A.[11]. The system is based on recent advances in the field of automation, on fail-proof inertial navigation systems, high-precision pulse-emitting hydrolocation instruments and earth satellite signals. The navigational conditions and the environment have no effect on the accuracy of the system. Positions can be determined to within 150 m. The system makes it possible to continuously determine the ship's longitude, latitude and course and transmit automatically to the helmsman the bearing and range to a predetermined point or to the destination point.

To permit passage beneath the ice in shallow areas and in straits, hydroacoustic submarine buoys can be used. These mark the channel where the depths are greatest in this region. Atomic submarines equipped with the above-described navigational instrumentation can detect and circumvent ice accumulations. In future, moreover, it will be possible for the atomic submarines to be provided with powerful icebreaker support. The icebreakers would operate the year round in the western and eastern regions of the Arctic. The submarines would need to be escorted in a small sector of the Northeast Passage (in the eastern part of Bering Strait year-old ice is usually 145 - 175 cm thick in winter).

In order to provide a safe navigation channel for atomic submarine

freighters in winter, to enable the icebreakers to prepare a site for them to surface, to rendezvous with them and, if necessary, accompany them in the vicinity of Bering Strait, an underwater hydroacoustic communications system can be used which was patented in the U.S. in 1966[11]. It makes possible simultaneous communication with a large number of units. The pulse-receiving and transmitting equipment which has an automatic transponder operates on an encoded channel which is specific to each unit. A special computer in the ship determines the coordinates. The system has special compensating equipment that allows for possible errors in range determination arising from the changing hydrological conditions of the sea and depth of submergence.

<u>The economics of under-ice navigation</u>. Atomic ships have certain advantages over ordinary ships, which can be summarized as follows. Voyages over great distances can be made at optimal maximum speeds and engine capacities. This enables atomic ships to transport a greater quantity of cargo over a given time span than is possible with conventionally powered ships. The gain is achieved on account of the increase in the cargo weight to fuel weight ratio. The absence of wave-induced resistance enables the atomic freighters to develop much higher speeds (up to 40 - 50 knots). At depths of 40 - 70 m atomic submarine freighters are unaffected by the meteorological conditions above the ocean surface (below-freezing temperatures, gale-force winds, worsening of the ice conditions). As stated earlier, under-ice navigation makes possible a 2 - 2½ times reduction in the length of the intercontinental trade routes.

In this case, atomic submarine freighters can transport cargo from the Arctic regions in winter, when the water masses become ice-bound. A nuclear ship with a greater horsepower increases relatively little in dimensions, weight and cost[3]. Finally, nuclear fuel is half the cost of conventional fuel.

It is precisely these advantages which make it possible for atomic ships, despite the higher construction and operating costs, to reduce considerably the relative cost of shipments, as compared with vessels fitted with conventional engines.

There is a considerable reduction in the time required to transport freight on the various routes. In favourable weather, a freighter with a speed of 20 knots covers the distance between Le Havre and Yokohama, which is 11,050 miles, in 23 days. In travelling at the same speed under water from Le Havre to Yokohama via the North Pole, a submarine shortens the distance between the ports by up to 6,000 miles and covers it in 12½ days.

In the sixties, at least 40 to 50 experimental planning studies and designs of various types of submarine freighters were developed in the United States, Britain, Japan, Norway and France[6].

In the United States, for example, a division of the American shipyard "Electric Boat" collaborated with the United State Merchant Navy in developing 27 versions of atomically-powered submarine tankers with dead weights ranging from 20,000 to 40,000 tons. The speeds of these vessels ranged from 20 to 40 knots. Other American shipbuilding firms engaged in atomic submarine construction also believe that the establishment of a fleet of atomically-powered submarine freighters is technically feasible. The General Dynamics Company submitted proposals to five U.S. companies for the building of six atomic submarine tankers, each with a dead weight of 170,000 tons. These tankers are intended for the shipment of Alaskan oil beneath the Arctic ice along the shortest routes to the regions of consumption. These proposals were submitted after a detailed technical evaluation had been made of the possibility of building tankers of this type and following an economic analysis of the effectiveness of their use.

British companies, working in conjunction with the American-owned Atomics Company, have developed designs for a nuclear-powered submarine ore carrier for under-ice shipments of iron ore from the Hudson Bay region to British ports.

Norwegian specialists have designed a number of nuclear-powered submarine freighters for the shipment of general cargo. For the design of the prototypes they used United States nuclear-powered naval submarines.

We made a calculation pertaining to the transportation of dry cargoes between Le Havre and Yokohama via the Arctic Basin. For this purpose we used the atomic submarine freighter proposed by Norwegian specialists which has the following parameters: net cargo capacity, 8,600 tons; length, 135 m; diameter, 15 m; depth of submergence, 80 - 100 m; capacity of the nuclear power unit, 48,000 hp; speed, 30 knots[5].

The calculations point up to the economic efficiency of delivering cargoes by submarines. As is the case with conventional freighters, the reduced costs per ton of cargo transported by the ship serve as the aggregated economic indices in estimating the economic efficiency of nuclear-powered submarine freighters.

This index is:

$$\text{Costs}_{e.a.} = P + E_1\text{Cap} + E_2Q_{fr} \ \frac{\text{dollars}}{\text{ton}};$$

where

$\text{Costs}_{e.a.}$ = the efficiency-adjusted costs per ton of freight transported;

P = the prime cost of shipping one ton of freight;

$E_1 = 0.1$ = the standard budgetary coefficient of capital investments in marine transport;

Cap = the unit capital investments per ton of freight transported $\left(\frac{\text{dollars}}{\text{ton}}\right)$;

$E_2 = 0.15$ = the standard efficiency coefficient of the working capital incorporated in the freight;

Q_{fr} = the losses resulting from freezing of the working capital incorporated in the freight during its transportation.

The prime cost of shipping one ton of freight P is defined as the ratio between the annual operating costs in dollars and the annual carrying

capacity of the ship on the route in question, in tons.

The unit capital investments per ton of freight transported are defined as the ratio between the cost of constructing the ship, in dollars, and the annual carrying capacity of the ship on the route in question, in tons.

In analyzing the trend towards the development of nuclear-powered shipping, the costs of operating these ships and the likelihood that they will be further developed during the remainder of this century, we calculated the cost of building a nuclear-powered submarine freighter and its operating costs, using as a model a ship with the above-stated parameters. Its cost is estimated as $15,000,000 and the annual operating costs as $2,400,000. The annual carrying capacity of a nuclear-powered submarine freighter operating across the North Pole between Le Havre and Yokohama is approximately 270,000 tons, and the estimated efficiency-adjusted costs of transporting one ton of freight are roughly $18 to $20.

In order to transport 20,000,000 tons of cargo between Europe and the Far East (across the North Pole), approximately 74 nuclear-powered submarine freighters would be needed, each with a carrying capacity of 8,600 tons. We estimate the cost of building them to be roughly $1,100 million to $1,200 million. The return of the capital cost of building the nuclear-powered submarine freighters is equal to the triennial saving in funds which would result from switching the freight flow of 20,000,000 tons from surface vessels to nuclear-powered submarine freighters.

At present, freight flows between Japan and Europe are running at a stable level. Japanese specialists have calculated that by 1985 Japanese exports will have undergone a thirteenfold increase and attain a value of $181 billion. Imports will increase to roughly the same extent and amount to $156.6 billion. It can be assumed that freight flows between Japan and Europe will increase significantly in the future and that the requirement for a nuclear-powered submarine fleet will be urgent.

In the United States, theoretical designs were worked out for a sectional submarine towed tanker, towed modules, an atomically-powered submarine tanker, and an ice-breaking tanker. We have obtained all of the information presented below from Reference 13.

On the sectional tanker a power unit of 8,000 hp is envisaged for the pumps (discharging the oil and operating the ballast trim), as well as a 10,000 hp braking unit which would make it possible to stop a tanker moving at an initial speed of 10 knots in 50 minutes, the inertial distance being 7.5 km. The oil pumps would be able to decant 720,000 tons of oil in 8 hours. The sectionally-built tanker would have the following advantages: 1) each section would be 7.62 m high, which would make it possible to operate it at an ordinary jetty with moderate depths; 2) the total requirement for construction steel is half that of an ordinary submarine vessel with the same dimensions; 3) it would be able to negotiate shallow areas in the extended position.

The tanker is assumed to consist of eight sections. Each section has the following dimensions: height, 7.62 m; width, 60.96 m; length, 484 m. The tanker's total displacement would be 900,000 tons, its cargo capacity, 720,000 tons of oil, and the cost $62,400,000.

Situated within each section would be the oil, ballast and mechanical tanks. The latter incorporate the electric motors, ballast pumps and ducts. All of the sections have independent buoyancy. The operation of a sectional tanker is accomplished by means of an electronic computer which processes data from 200 sensors collecting information on depths, temperature, the extent to which the ballast and stabilizing tanks are filled, the stresses in the structural couplings, the positions of the sections, etc. The sections themselves would be built of cladded reinforced concrete and structural steel.

The costs of the towing units for a sectional tanker and the towing speeds have been calculated. The costs of the different versions of the towing units are: 1) an ocean-going tug with an effective horsepower of 44,000, enabling it to tow the tanker at a speed of 13 knots - $19,000,000; 2) a tug with

a conventional propulsion unit of 32,000 hp capacity, capable of cutting through ice 1.5 m thick and towing the tanker at a speed of 11 knots - $60,000,000; 3) a nuclear-powered towing module of 32,000 hp, capable of pulling the tanker at a speed of 11.6 knots - $90,000,000.

The cost of building an icebreaking supertanker with a dead weight of 250,000 tons, a capacity of 120,000 hp, and a speed of 22 knots in open water is $75,000,000. A conventionally powered module with an electric engine could tow a sectional tanker under the water over a distance exceeding 2,000 miles at a speed of 5.3 knots.

The route selected for the oil transportation calculations was Prudhoe to the Delaware River, which is a distance of 4,335 miles. On this route 1,900 miles are accounted for by open water between Greenland and the Delaware River; 1,035 miles are near the Greenland coast, where icebergs are encountered, and 1,400 miles separate Greenland from Prudhoe Bay, where the conditions are very treacherous.

The cost of transporting the oil was determined by the daily costs for the different types of transport, the proportion of the round voyage pertaining to one day of operation, and the carrying capacity. The results of the calculations of the transportation costs for the various types of transport and methods of transportation are presented in Table III.

The calculation of the version which entails using a nonself-propelled sectional tanker was made in the following way: from Prudhoe Bay (Alaska) the loaded tanker is towed by an underwater powered module to the west coast of Greenland, where it is met by an empty sectional tanker which has been towed for a rendezvous with it from the Delaware River area (eastern seaboard of the United States) by an ocean-going surface tug. Near the west coast of Greenland a change of traction is effected, i.e., the ocean-going tug returns to the Delaware River with the loaded tanker and the underwater module tows the now empty tanker back to Prudhoe Bay.

Table III

Transportation costs for various ships

Index	Sectional underwater tanker	Diesel surface module		Submersible module		Nuclear-powered module	Tugs		Ice-breaking tanker	Tanker	Nuclear-powered underwater tanker
		In ice	In open water	In ice	In open water		In ice	In open water			
Power, eff. hp	10,000	32,000	24,000	6,000	5,000	32,000	44,000	20,000	120,000	11,000	80,000
Speed, knots	-	11	10	5.6	5.3	11.6	13	10	(from 2 to 15)	10	18
Capacity, millions of barrels	5.3	-	-	-	-	-	-	-	1.8	1.8	1.2
Initial cost, millions of dollars	62.4	60.0	60.0	60.0	60.0	90.0	19.0	19.0	75.0	75.0	180.0
Amortization, technical servicing, repairs, etc., thousands of dollars	37.4	36.0	36.0	36.0	36.0	54.0	11.4	11.4	45.0	45.0	108.0
Fuel or batteries, thousands of dollars .	-	3.2	2.4	20.2	17.3	3.2	4.4	2.0	12.0	1.1	8.0
Maintenance of crew, thousands of dollars .	-	5.0	5.0	5.0	5.0	5.0	3.0	3.0	5.5	5.5	6.0
Total daily expenditures for the various ships (including the sectional underwater tanker), thousands of dollars	-	81.6	80.8	98.6	95.7	99.6	56.2	53.8	62.5	51.6	122.0

In the calculations for the use of the nuclear-powered submarine tanker and the icebreaking tanker the transportation costs for both sections of the route were combined, to which was added the cost of transportation in the southern part of Greenland (4 cents per barrel).

Depending on the season, the round voyage of the conventional and the nuclear-powered module with the tanker section in tow takes from 37 to 41 days. The round voyage of the icebreaking tanker between Prudhoe and Greenland, again depending on the season, is 9 to 39 days, whereas in the case of the nuclear-powered submarine tanker the figure for the same route is 11.3 days, regardless of the time of year.

The final results of the calculations of the over-all annual cost of transporting a ton of oil from the vicinity of Prudhoe Bay to the Delaware River by various types of transport are characterized by the following data:

Delivery variant	Unit transportation costs, dollars/barrel	Unit transportation costs, dollars/ton
Underwater sectional tanker with conventionally powered module	0.0498	0.31
Underwater sectional tanker with nuclear powered module . .	0.0442	0.27
Icebreaking tanker* . . .	1.136	7.0
Nuclear powered underwater tanker	1.376	8.5
Pipeline through Alaska to the U.S.A.	1.200	7.4

* The costs for the icebreaker escort are not included in the figure for transporting the oil by the icebreaking tanker.

The figures for the pipeline are probably on the low side, since the initial cost of an oil pipeline in Alaska extending from Prudhoe to the port of Valdez (south coast of Alaska) were estimated as $900,000,000, and the cost of construction subsequently rose to $3 billion. At the present time, a

deep water seaport is being developed in the vicinity of the Canadian Arctic islands for exporting oil, the reserves of which in the American Arctic are estimated to be 40 billion tons.

Thus, the calculations indicate the economic expediency of delivering cargoes from Europe to the Far East along the very short under-ice route, and also the importance of this type of transport in developing the natural resources of the northern regions.

Underwater ships and preservation of the environment. At the present time a great deal of attention is being directed towards preventing the seas from being polluted by petroleum wastes discharged by thousands of ships using conventional fuel. As is well known, one ton of light oil is capable of covering an area of sea equivalent to 1,200 hectares. Petroleum wastes are dangerous because they lead to the polluting of extensive areas and are resistant to decomposition.

Atomic vessels do not pollute the oceans. The design of the nuclear-powered engines is such that there is no fallout of radioactive materials into the environment even in the event of damage being sustained. In order to combat fire hazards in nuclear-powered ships, fire-resistant bulkheads are used, as well as sprinkler-type extinguishers and automatic signalling. To protect the reactor from disintegration in the event of the ship colliding or becoming stranded on a shoal special provisions have been incorporated in the design of the hull. Should it be necessary to flood the ship the integrity of the reactor is assured by encasing it in a special container or by setting up a counter-pressure within the reactor by means of automatic valves.

In peacetime, cases of serious damage in submarines are very rare. Thus, during the past 30 years there have been only three submarine disasters: the conventional "Squalus" (1939) and two nuclear submarines - the "Thrasher" (1963) and the "Scorpion" (1969). No increase in radioactivity was detected in the vicinity of these nuclear-powered submarines. The number of nuclear submarines has continued to grow and in the sixties there were 100 of them in the

United States fleet. Every year they make up to 50,000 dives.

In the United States, under the DSRV plan, two special deep-water diving rescue units are being built, one of which will be operational and the other held in reserve. It is assumed that the rescue system will be able to be transported to any point on the globe within 24 hours of receiving a distress signal. As G. Soul has pointed out[9], the rescue ship will be able to go to the aid of a nuclear-powered submarine that has been damaged under the ice sheet in the Arctic.

As accidents are very rare, specialists believe that the rescue ships will be used mainly in research work.

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VI. COMMUNICATIONS AND INFORMATION

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REGIONAL STUDIES IN RESEARCH INSTITUTIONS OF THE NORTHEAST OF THE U.S.S.R.

Directives of the XXIV Congress of the C.P.S.U. on the five-year plan for economic development of the U.S.S.R. during the period 1971-1975 provide for accelerated development of resources in the Northeast of the U.S.S.R. This region is unique with respect to its resources; moreover, it has distinctive environmental and climatic conditions determining the need for specific methods of economic development. Science therefore faces important tasks related to the identification and appraisal of resources in this area, devising ways for incorporating them into the economic turnover, and reducing the effect of high cost factors.

A number of research establishments and institutions of higher learning are functioning at present in the territory of the Northeast of the U.S.S.R. The Yakut Branch of the Siberian Division of the Academy of Sciences, U.S.S.R. is the largest establishment of this type. It comprises five institutes: the Geological Institute, Institute for Space Physics and Aeronomy, Institute of Northern Physico-Technological Problems, Biological Institute and Institute of Linguistics, Literature and History. Furthermore, this Branch of the Academy of Sciences has a Department of Economics, a Department of Computer Mathematics and Technology, and Botanical Gardens. The Permafrost Institute of the Siberian Division, Academy of Sciences, U.S.S.R., and other research establishments, are operating in Yakutsk.

"Yakutniipromalmaz", a design, innovation and research institute

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of the Ministry of Nonferrous Metallurgy, has been established in the city of Mirnyi, the centre of diamond mining.

Significant amounts of research are done at the Yakutsk State University. A total of 6,500 students (full-time, part-time or by correspondance) are registered in the seven departments of the university providing training in 16 specialties. Graduates from the university form the main bulk of professionals in the Republic.

Yakut scientists are engaged in research in the field of geological and mineralogical, physical and mathematical, biological, engineering and other sciences. They have made a significant contribution to the development of the economy and culture and science and technology in Yakut A.S.S.R.

Science is also rapidly advancing in Magadan Oblast. The organizations operating here are as follows: the Northeastern Interdisciplinary Research Institute of the Far-Eastern Centre, Academy of Sciences, U.S.S.R., Institute of Northern Biology of the above Centre, All-Union Gold and Rare Metals Research Institute (NII-1), Magadan Branch of the Pacific Institute of Fisheries and Oceanography, Magadan Zonal Research Institute of Agriculture, etc.

At present, regional science is facing important tasks in the field of scientific and technological forecasting of integrated economic development, drafting programs for the social and cultural advancement of the region, etc.

The new stage in the development of Northern Asia, a stage involving immense capital investments and integrated development in the region, should be matched by a radically new approach to the development of science. We are not referring to a straightforward increase in personnel of the existing institutions, or to expanding the scope of research conducted in them, but to a significant rise in the level of development and the role of science so that scientific establishments would be capable of solving specific theoretical and applied problems related to prospecting for natural resources and their

appraisal, working out ways and methods for incorporating them into the economic turnover, developing industrial machinery, equipment and technology for the socio-economic development of the region. This will necessitate evolving a number of new scientific trends.

In our opinion, a promising solution is to create in the Northeast a regional scientific centre. It would be based on the general pattern of territorial distribution and institutional scientific specialization in different regions of our country. The identification of specific regional features and of their effect on the processes and phenomena examined, and the development of theoretical principles, making it possible to take these factors into account in economic practice, require in the overwhelming majority of instances a distinctive theoretical and methodological approach. Experience has repeatedly demonstrated the failure of attempts to transplant mechanically into the North theoretical and technological solutions, methodological principles and universal norms developed for use in the Temperate Zone. Such attempts lead to certain miscalculations and are detrimental to the national economy.

The development of research on applied regional problems does not, however, exclude studies of methodological and theoretical nature; it presumes that such studies will be conducted.

The above does not imply the organization of research in every sector of science or the establishment of research institutions representing every scientific trend in every region of our country, including the Northeast. Duplication of the work conducted by central institutes would contradict the Party directives to the effect that all forces and means must concentrate on solving the most urgent problems. Even in developing new machinery and equipment, materials and technology for the North, there is often no need to establish special institutes for the northern regions engaged in this type of research, provided the problems are effectively solved in central research institutes, which are better equipped in terms of highly qualified personnel and experimental facilities.

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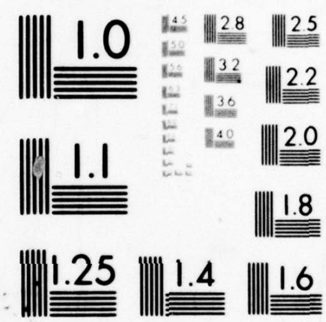

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

While organizing scientific institutions in the Northeast, it is imperative to take into account important factors such as the high cost of labour resources, the difficulty involved in staffing the institutes with highly qualified specialists, in creating a favourable climate for creative work and normal cultural and living conditions. It is therefore expedient to develop first of all the branches of science designed to solve the regional problems, the solution of which in central institutes is impossible or inexpedient. In brief, scientific establishments in the Northeast, like those of other remote regions in our country, should focus on theoretical research in the areas related to solving regional economic and socio-economic problems.

In our opinion, the city of Yakutsk could become the regional scientific capital of the Northeast. It has already evolved into a large scientific centre with specialists representing all major trends of modern science. Moreover, the necessary reserve of local specialists has been trained with a view to preparing a replacement for researchers engaged in different branches of science and technology. In terms of environmental, climatic and other conditions Yakutiya is a typical northeastern territory effectively embodying the most characteristic features of the other northeastern regions. Most engineering solutions and recommendations developed for Yakutiya can be implemented in any other region of the Northeast with minor corrections for local conditions.

The main trends of research in the field of regional geology and geophysics should concentrate on studies of the deep-seated structures of the earth's crust and those of the upper mantle, formational processes of the earth's crust (tectonics and stratigraphy), patterns of formation and distribution of caustobiolith deposits (oil, gas, coal), gold, tin, tungsten, nickel, copper, aluminum, antimony, mercury, diamond and other deposits, as well as forecasting the discovery of deposits.

In the field of physico-mathematical sciences it is imperative to develop further space physics research and aeronomy, to study the specific problems related to radio communication in high altitudes, as well as remote

sensing techniques, and to continue research on the magnetic field of the earth.

Studies of super-high energy particles should occupy an important place among these investigations.

Research in the field of engineering physics is particularly urgent under specific northern conditions. In order to solve these problems, the Institute of Engineering Physics was created in 1970 as part of the Yakut Branch of the Siberian Division, Academy of Sciences, U.S.S.R. The Institute is engaged in integrated research in engineering physics aimed at ensuring a high rate of engineering progress in different sectors of the national economy. The Institute conducts research directed at improving mining technology and extending the annual duration of mining operations under the conditions of permafrost and low temperatures, as well as research on engineering geology aimed at increasing the reliability of basements and foundations, frost-resistance of machinery, materials and welded joints, etc. In order to determine the adaptability of different machinery and equipment to northern conditions, it is necessary to create a special integrated experimental facility ("natural laboratory") for testing machinery, mechanisms, equipment, materials, technological and monitoring systems.

The northern environment affects primarily the operations of the mining industry. The fundamental research aimed at developing advanced technology and methods for mining minerals, integrated mechanization and automation of mining under low-temperature and frozen-ground conditions must focus on devising radically new technical solutions with respect to the extraction of all the useful components from the ore in order to reduce and eventually overcome the seasonal character of mining operations.

Geocryological research is an important area of regional studies in the Northeast. Intensive economic development of the northern regions necessitates further research into the patterns of distribution of permafrost and of the cryogenic phenomena associated with them, studies on the properties of permafrost, theoretical substantiation of seismophysical, physico-mechanical,

geochemical and other processes taking place in permafrost and frozen soil. The distinctive geocryological features established in each specific region must be used to formulate practical recommendations for taking into account permafrost factors in designing, construction, mining, land development, etc.

It would be of great theoretical and practical importance to elucidate the laws governing the formation of underground waters and to develop optimal techniques for harnessing these waters to supply populated centres. A new regional trend - multilateral studies on the migration of ore components in underground waters - must also be developed.

To improve further the quality of research, the Institute of Permafrost Sciences must apply extensive quantitative and precise physical methods, which could provide the possibility of developing methods of controlling cryogenic processes. To solve effectively the problems outlined above, the experimental base of the Institute must be expanded and strengthened.

The Northeast of the U.S.S.R. has enormous soil, vegetal and faunal resources. It is rich in valuable commercial fur-bearing animals, the yield of which on the territory of Yakutiya alone amounts to a significant percentage of the planned output of commercial pelts in the U.S.S.R. Biological resources must be studied to ensure their maximum and optimum utilization in the national economy; moreover, experiments in acclimatization of new highly-productive animal and plant species on the territory of the Northeast of the U.S.S.R. must be carried out.

Prerequisites have now been completed for transition from the hitherto prevalent methods of identifying and recording the phenomena studied to the next stage, i.e., to experimental research aimed at developing means of purposefully controlling biological processes under the extreme environmental and climatic conditions of the Northeast.

Agricultural sciences should develop scientific premises for creating a stable feed base by improving soils in hay meadows and pasture

grounds, by optimizing hay production and by improving markedly the quality of hay, through the introduction of cultivated pasture grounds, improvement of cattle, horse, reindeer and wildlife breeding programs, through the liquidation of sterility and barrenness, as well as losses among the young stock, by promoting intensive rearing of young cattle. The introduction of commercial poultry breeding demands that a scientifically substantiated system of management in this field be developed. In the area of farming, work in the selection of cereal crops must continue to develop new high-yielding varieties resistant to drought and cold. One of the urgent tasks in the field of agricultural sciences is to develop and implement an intensive system of open-ground vegetable and potato cultivation, as well as commercial truck gardening in greenhouses and hotbeds. Agricultural economists should develop means for further improving the specialization and distribution of individual industries in different zones, regions and farms, and in their production subdivisions. The solution of these problems will greatly increase the economic efficiency of agricultural production through its intensification.

In view of the intensive development of natural resources in the Northeast, the growing rate of settlement in the northeastern regions, and development of a modern material and technological base, it has become imperative to expand and develop in depth economic investigations. Economic sciences are responsible for developing the means of long-term forecasting and modelling of the optimum economic, socio-economic and cultural development of this vast and distinctive region, and for working out scientific premises of regional economic and technological policies.

Science must provide well-substantiated solutions to the vital regional problems, such as the economic evaluation of natural resources in the region, optimum ways, methods and stages of their economic development, the most effective trends for capital investment, ways and means of overcoming the high cost factors in capital construction and production, and identification of the potentials for improving the economic effectiveness of work in northern enterprises.

Another important task is to formulate the rationale for the

methodology and methods of developing regional norms and standards for the use of labour, raw and other types of material, fuel and energy, and for the depreciation of machinery and equipment under northern conditions.

Further development in the social sciences and an increase in their role in communist construction demand the expansion of research in the fields of history, philosophy, sociology, archeology, ethnography and the arts. Eighteen different ethnic groups (the Eveny, Evenki, Yukagiry, Dolgany, Nganasany, Chukchi, Eskimosy, Nentsy, etc.) live in the Northeast of our country alongside the Yakuty. They all have their own history, language, specific culture and national traditions, and have created a rich folklore and original art.

The further cultural evolution of these ethnic groups requires fundamental scientific studies and summarization of experience in cultural development, as well as scholarly research into the problems of linguistic evolution, development of literature and folklore, and studies of current social and ethnic processes.

To ensure scientific progress and increased effectiveness of the work conducted by research institutions, an appropriate material and technological base must be created for the growing research establishments of the Northeast, new establishments (institutes of economics, regional geology and geophysics, mining, etc.) must be organized, and the systematic training of research personnel must be expanded considerably.

The training of research personnel must take into account the new trends emerging in science. The main task is to develop a stable group of highly qualified researchers, mainly from among the talented young permanent inhabitants of the North. The required research personnel could be developed by expanding the higher education of professionals in the North, as well as in centrally located cities of the country.

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ENVIRONMENTAL CONSERVATION AND DEVELOPMENT OF A TRANSPORT SYSTEM IN THE NORTH

The unique mineral deposits discovered recently in the North are located in regions thousands of kilometers away from the areas of consumption. Transport therefore determines the scale, or even the feasibility, of developing a given deposit. With the existing transport system, from one to two years are required to deliver freight, with several transshipments, to such localities, and the cost of transporting freight to some deposits is very high. The rate at which the resources of the new northern territories will be developed therefore depends to a significant degree on the solution of transportation problems.

The transportation portion of the total production cost is, on the average, fairly high (up to 12 - 13 %). In northern regions, however, the cost of transportation is 2 - 3 times greater [1,3,5].

Historically, the existing means of transportation had been intended and designed for temperate climatic regions. Modern aviation constitutes an exception, since its technical capabilities are calculated for operation under both ground conditions (normal atmospheric pressure and temperature of the central belt) and high-altitude air conditions (rarified atmosphere, low temperature, powerful air currents).

In the North, conditions are more complex than in the temperate zone.

Problemy Severa, (18): 228-232, 1973.

The limited range of conditions under which the available transportation modes can operate and the close dependence of transport on the environment are responsible for the seasonal nature of freight movement to the northern regions. Between seasons the freight is stored in sheds, and depreciates. Depreciation of the freight is the more significant, the harsher the environment. The volume of freight in transit serves as an index of the complexity of environmental conditions, reflects their effect on different modes of transport, and determines the percentage value of the transportation component in the high cost factor pertaining to work conducted in the North.

One of the most urgent tasks is to determine optimum areas for the use of conventional modes of transport and to establish transportation trunk lines. In developed regions, where the organization of a transportation system is complicated by tradition and by the facilities already available, as well as by the capital invested, the radical restructuring of the system is difficult, often even inexpedient. In newly developed regions, however, the transportation system can be organized from the very beginning on a scientific basis, through the selection of optimum solutions and with minimum damage to the environment. The optimization of transport operations can be achieved only on condition that the transport network be regarded as a system, i.e., the sum total of the means of communication comprising every type of transport, transportation centres and transport equipment. This requires effective cooperation and coordination in the work of different types of transport in order to determine accurately the sphere and duration of activity of each individual mode of transport, taking into account technical, operational and economic indices.

The essence of the system rests on the following three main principles: functional compatibility, rationalization, and centralization. The principle of compatibility reflects the need for the presence and interaction of uniform elements. Such elements are the different modes of transport. However, the system presumes their interaction, rather than isolated utilization. The principle of rationalization of functions reflects the diversity of properties and the need to alter the direction and content of transportation flow in order to preserve the system as a whole. The principle of the concentration of functions

reflects the need to coordinate the functions as such and, while doing so, to indicate the essence of the coordination. All the principles must ensure the achievement of the main goal, i.e., the fulfilment of the required volume of shipments with a minimum expenditure of manpower and capital.

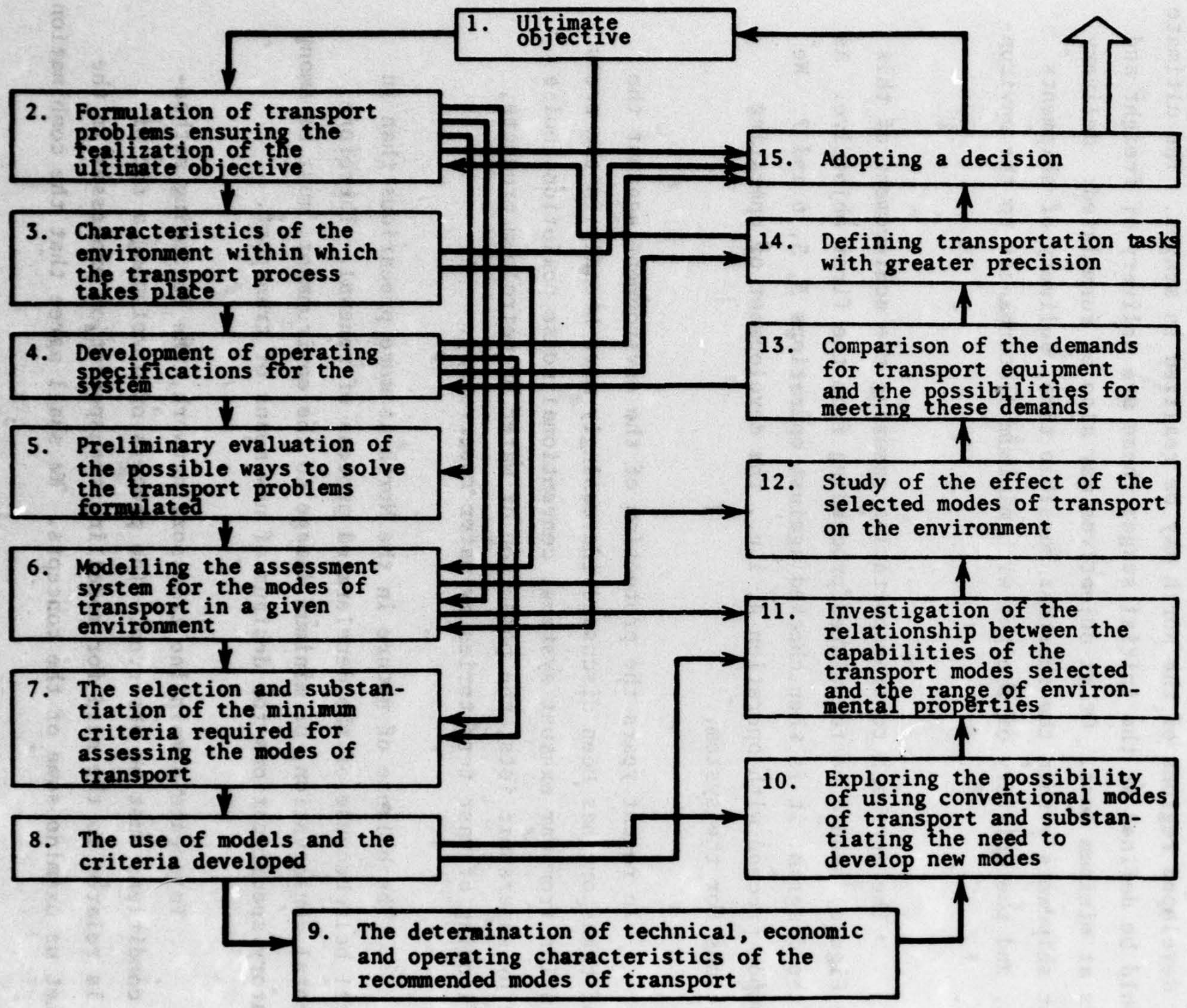
The consecutive development of transportation trunk lines for the newly developed regions of the North may be realized in stages. The ultimate goals should be defined at the initial stage; these are delivery of freight and passengers at minimum cost. Other objectives may also be formulated: delivery of freight shipments within the shortest possible time, delivery of shipments undamaged, and the delivery of freight with minimum disturbances to the environment, etc.

The approach to transportation ensuring the achievement of this goal (see Figure) should be formulated proceeding from the first objective. As shown in the diagram, it is then checked against operations 3, 5, 6 and 7. We can thereupon proceed with operation 4, i.e., the development of operating specifications for the system.

In recent years the protection of the environment against the effects of transport has been discussed increasingly more broadly in the press (air pollution from car exhaust systems, conventional noise pollution, noise pollution by supersonic jets, the pollution of water by petroleum products, and the flooding of vast territories by water reservoirs).

The balance of nature in the North is more precarious than in the central belt because of the decelerated process of renewal. Therefore, environmental conservation, or minimum damage to the environment, must be among the mandatory specifications for designs of new means of transport.

To create a mainline transport network, the following methodological conditions must be observed. The process of developing a set of criteria is related to the need for modelling transportation processes in the North. Let us examine some of the concepts. We shall agree that the combination



Figure

Diagram illustrating the sequential development of a transportation network for a newly developed region in the North

of operations which must be performed in handling freight in order to deliver it from the shipper to the consignee, will be referred to as the transportation process. This set of operations includes: packing the freight, filling in the necessary shipping documentation, storage of the freight while waiting for the opportunity to ship it by one or another means of transport (for example, waiting for the opening of navigation or for the establishment of winter roads), its loading, transportation proper (including transshipment), unloading, storage at the point of destination, loading of the freight by the consignee, its unpacking, etc. As was demonstrated earlier[2], all these operations are significantly costlier with respect to labour, time and equipment than analogous operations in the temperate zone of our country.

Any product of socially useful labour in the amount, and with the quality indices specified by the consumer at the point of destination, shall be referred to as freight. The weight of packaging determined by the specific conditions of shipment by one or another mode of transport or by the need to preserve the goods shipped to the North, as well as the weight of the fuel required for moving the freight, and the quantitative and depreciation losses of freight in shipment, are thus excluded from the above definition.

We shall define the duration of the interval during which the freight is in transit t, as $T_2 - T_1$, where T_2 is the moment at which the consignee receives the freight in the form ready for its designated use, while T_1 is the moment at which the goods are delivered for shipment. The length of the time interval during which the freight is in transit is equal to the total time of shipping freight by all modes of transport plus the time spent on the initial and final, and loading and unloading operations, and that spent in storage at the initial, intermediate, and final points.

The seasonal nature of shipping freight in the North makes it necessary to accumulate reserves of freight at both shipping and destination points. At the shipping point the reserves form as a result of continuous production, while at the point of destination they are formed to provide for uninterrupted consumption during the period when no deliveries of the freight

take place. Moreover, when freight is transshipped from one mode of transport to another, it must also be stored at the transshipment point. The seasonal nature of freight shipments in the North implies increases above the norm of freight reserve in storage at the point of destination. While in conditions of a stable and secure transport process in the temperate zone the standard reserve of freight goods is equal to the amount required for consumption over the period of one and a half months, in the event of seasonal shipping of freight, characteristic of the North, the standard reserve must be increased at least to a year: the interseasonal gap plus the time required to ship the freight by the final link in the transport system. All this leads to the depreciation of freight goods in transit. We have attempted to assess the effect of freight volume on the economic indices of the transport system, but thus far the problem has not been solved definitively. At the same time the development of a transport system for the North must yield the main effect: i.e., reduce the time during which the freight is in transit, and hence improve substantially the economic indices.

The next criterion of the transportation process is the distance S over which the freight is moved. It is assessed from the route covered by the mode of transport moving the freight. The distance may vary for different modes of transport and is determined by the specific features of the mode of transportation: the need for vessels to follow winding river courses, and for railroad and highway transport to observe admissible slopes. Taking this into account, it is suggested that the distance be defined as the straight geometrical line linking the initial and the final points of the route. Any deflections from this straight line owing to the specificity of the modes of transport used should be taken into account separately in evaluating its effectiveness.

The above allows us to determine the speed (v) of the transport process as the quotient obtained by dividing the route (S) by the time (t). The results obtained characterize more accurately, in our opinion, the actual speed of transportation processes within the system than do data on the maximum or even mean velocities of trains, planes or trucks.

The calculations should take into account the resistance that must be overcome by the freight in transit from the point of dispatch to the point of destination. This concept may include all the factors reducing the speed of the mode of transport independent of inhibiting factors (environmental resistance, i.e., the weather delaying a trip, the time required to complete documentation, etc.).

The power N generated by the engines installed in any of the modes of transport is the only source of energy consumed for the transport process (the consumption of energy for the loading, unloading and storage can be ignored). We shall therefore consider that the total power of these engines is consumed to overcome the resistance mentioned earlier. According to the equation $N = P \cdot V$, the power required to transport freight when the motion is uniform is then equal to the resistance force of the transportation system, defined by the formula $P = N : V$.

Optimization of the transport process should proceed along the lines of searching for solutions (modes of transport, methods of shipments, integrated solutions) at which environmental resistance is minimum. Only then can we attain the ultimate goal - to deliver freight at minimum cost (of power, energy and resources).

The provisions examined above appear to be applicable for evaluating the effectiveness of the solutions adopted while developing the system of transport.

Once the criteria have been worked out, we can proceed with the development of a model and with defining technical, economic and operating specifications of the modes of transport recommended.

Once the combination of the modes of transport ensuring the achievement of the final goal (positions 10 and 11 in the diagram) has been determined, the modes selected can be examined with a view to determining their effect on the environment. Optimizing the solution with respect to this

parameter will make it possible to proceed with the concluding stages in the development of the system.*

Many organizations have gained accumulated experience in the field of environmental protection in newly developed regions. For example, the winter highways built according to the SevNIIP's method[4] make it possible to leave the frozen ground undisturbed in the places where the roads are built. Automotive shipments in the winter over river ice are highly effective and contribute to the conservation of the adjacent forests. The recently developed track road ensures minimum environmental interference in the process of transporting freight.

The protection of the environment in the process of developing new northern regions can be ensured only if qualified scientific personnel are involved in preparing the solutions from the earliest stage, and if the process of development as such, in the field of transportation in particular, is conducted according to system design methods.

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* The methods outlined in the diagram have been developed with the active participation and assistance of V. K. Korsak.

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PROBLEMS RELATED TO THE USE OF FUEL RESOURCES IN THE EUROPEAN NORTH

The successful restructuring of the national fuel balance resulting from a shift in exploitation priority to the most economical kinds of fuel (gas, oil and open-pit coal), has proven highly advantageous in economic terms. In 1966-1970 the economic gain from the use of the most efficient types of fuel amounted to over 3 billion rubles.*

An increase in the proportion of gas in the fuel balance has a favourable effect on the environment, since discharges of ashes and sulphur into the atmosphere are practically nil during the combustion of gas.

In 1960 the percentage of gas and oil in the total fuel output was about 40%; in 1970 it increased to 60% and is expected to reach 67% in 1975. This will require escalated development in the oil and gas industry.

The use of gas and oil in the fuel balance is expedient, primarily in the regions where their substitution for coal is most advantageous economically. These are the central and western regions of the European U.S.S.R. (the North-western, Baltic, Volga-Vyatka, and Central regions, as well as the Byelorussian S.S.R.). Until recently oil and gas had been produced mainly in the European zone, a circumstance favourable to the fuel economy. It allowed us to restructure the fuel balance in this area using its own resources, even to ship a portion of the fuel to the east (transporting oil via the Al'met'evsk - Omsk - Irkutsk pipeline).

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* "Gosudarstvennyi pyatiletnii plan razvitiya narodnogo khozyaistva SSSR na 1971-1975 gody" (The State five-year plan for the development of the national economy of the U.S.S.R. in 1971-1975). Politizdat, 1972, p. 97.

Problemy Severa, (18): 233-239, 1973.

The situation is now changing. The demand for fuel in the European regions is growing steadily, while the prospects for increasing the recovery of economic types of fuel in these regions are limited and will lag more and more behind the demand for such fuels. Most of the potential oil and gas reserves and nearly all the open-pit coal reserves are situated in the eastern regions of our country. To supply the European part of the country with fuel as economically as possible is therefore the crucial problem of the Soviet fuel economy in terms of its prospective development and distribution. Pipelining oil and gas is much cheaper than transporting these types of fuel by rail. Oil and gas are therefore the most economical types of fuel in the European regions, even when piped over considerable distances. Consequently, one of the possible solutions to the problem of fuel supply in the European zone is to pipeline it from the Eastern regions.

It is nevertheless imperative to accelerate the development of the oil and gas resources of the European regions; the Timan-Pechora oil- and gas-bearing province is of the greatest interest in this respect.

Data on the development and distribution of the oil- and gas-producing industries in the U.S.S.R. are shown in Table I.

The above data show that the northern share of the oil produced (both in the Asian and European North) will increase markedly in the total oil output of the U.S.S.R.

The oil industry throughout the European regions has already attained a high degree of development. It can only endeavour to maintain the current level of recovery in the coming years. In a number of regions (the Volga region, Northern Caucasus) the output of oil may be expected to drop somewhat. Under the circumstances the Timan-Pechora province gains markedly in importance, since the volume of its prospected reserves may justify the establishment of a new major oil-production base in this province.

The economic rationale for establishing such a base is its

Table I

Distribution of oil (together with gas condensate) produced in the major zones of our country (in % of the total output)

	1960	1970	1975*	Prospects (tentative estimates of the author)
European part of the U.S.S.R., including the Urals	92.8	81.9	63.8	40 - 50
Including:				
Northern regions (Komi A.S.S.R.). .	0.5	2.0	3.0	4 - 5
Asian part of the U.S.S.R.	7.2	18.1	36.2	60 - 50
Including:				
Northern regions	-	-	25.0	51 - 55
Among them the Far North	-	-	-	26 - 30
Total for the U.S.S.R.	100	100	100	100
Including:				
Northern regions (Tyumen Oblast, Komi A.S.S.R., Sakhalin)	0.5	2.0	28	55 - 60
Among them the Far North (northern part of Tyumen Oblast and Komi A.S.S.R.)	-	-	3	30 - 35

* "Gosudarstvennyi pyatiletnii plan razvitiya narodnogo khozyaistva SSSR na 1971-1975 gg." (The State five-year plan for the development of the national economy of the U.S.S.R. in 1971-1975). Politizdat, 1972, p. 103.

relative proximity to consumers in the European U.S.S.R. as compared to the eastern regions. So far, however, inadequate geological exploration of this region and of its oil reserves does not permit an unequivocal appraisal of the possible oil output. Different organizations therefore estimate prospective oil production in the Timan-Pechora province to be within the range of 25 to 60 million tons. Geological exploration of this highly promising region must be escalated. The Timan-Pechora province should be evaluated more fully and thoroughly with respect ot the quality and quantity of its reserves and size of its deposits, since these factors will determine to a significant extent the economic indices of oil production.

Up until the early 1960's oil was produced in the Komi A.S.S.R. from small deposits partly by way of mining, as a result of which the cost of production was high. Exploitation of the West Tebukskoe deposit significantly improved the output indices. Changes in the wellhead cost of oil in the Komi A.S.S.R. are illustrated by the following figures (in % of the mean data for the industry):

	1960	1965	1970
U.S.S.R.	100	100	100
Komi A.S.S.R. . . .	320	156	144

Preliminary estimates provided by research institutions show that according to efficiency-adjusted costs, the prospective production of oil in the Timan-Pechora province appears to be highly favourable (in % of the mean data for the oil industry as a whole):

U.S.S.R.	100	Byelorussian S.S.R.	122
Western Siberia	56	Orenburg Oblast	134
Udmurt A.S.S.R.	94	Turkmen S.S.R.	137
Komi A.S.S.R.	114	Kazakh S.S.R.	154

It is obviously difficult to calculate the scope of future expenditures, considering the varying degrees of reliability of the initial information. A comparison of the economic indices obtained for different regions by using identical methods of calculations is, however, indicative of the relative economic effect anticipated from exploitation of deposits in different regions. As may be seen from the above figures, the Timan-Pechora oil- and gas-bearing province offers favourable prospects in this respect. In terms of the investments quoted above, this province ranks third among the most actively developing new regions, next to Western Siberia and the Udmurt A.S.S.R. A considerable portion of the oil produced in this province can be exported to the central European regions, since its output will exceed the demand for oil in the area adjacent to the Timan-Pechora province (the currently operating Ukhta Oil Refinery in Ukhta and the new oil refinery projected for Arkhangel'sk Oblast).

Development and location of our country's gas industry over the course of the current five-year plan period, as well as in the future, involves its relocation to the East, where about 70% of proven and unexplored gas reserves of the U.S.S.R. are located. A distinctive feature in the evolution of this industry is the development of giant gas deposits situated in the Far North of the European U.S.S.R., in Siberia and in regions equated to the Far North (in the Komi A.S.S.R., Arkhangel'sk and Tyumen oblasts, Krasnoyarsk Krai and Yakut A.S.S.R.). The output of gas in the northern regions is expected to increase in the future to 50 - 60% of the total gas production in the Soviet Union (Table II).

The gas industry has attained a high level of development in the main gas-producing regions of the European U.S.S.R. Much effort and many radically new solutions are needed to maintain it on that level. Such solutions may include, for example, the development of deep-seated deposits, etc. The output of gas in the major gas-producing regions (Ukraine and the Northern Caucasus and Volga regions) will, as was mentioned earlier, eventually become stabilized or will decrease. Development of new gas deposits is anticipated only in two regions: the Timan-Pechora oil- and gas-bearing province and the Orenburg Oblast.

Recent geological explorations revealed a significant promise of gas in the Timan-Pechora province, whereas in the past it was believed to be essentially an oil-bearing region. A number of large deposits(Vuktyl, Vasil'evka, Laya-Vozh, etc.) have been discovered. Moreover, it has been established that the province encloses considerably larger potential gas resources than was estimated previously.

According to recent data, about 40% of the total potential gas reserves from the European regions and Urals occur in the Timan-Pechora oil- and gas-bearing province.

Despite the high forecast indices, the geology of the province has so far been inadequately studied; only 7% of the estimated continental

Table II

Production of gas in different zones of the country*

	1960		1970		1975		Prospects (as estimated by the author) in % of total
	billion m^3	%	billion m^3	%	billion m^3	%	
European	43.7	96.5	136.7	69.0	137.0	42.8	20 - 30
Including:							
Northern regions . . .	1.0	2.2	6.9	3.5	16.1	5.0	7 - 8
The Urals	0.5	1.1	2.2	1.0	27.1	8.5	10
Eastern	1.1	2.4	59.1	30.0	155.9	48.7	60 - 70
Including:							
Northern regions . . .	-	-	9.7	4.9	47.5	14.8	45 - 50
U.S.S.R.	45.3	100.0	198.0	100.0	320.0	100.0	100
Including:							
Northern regions . . .	1.0	2.2	16.6	8.4	63.6	19.8	52 - 58

* "Osnovnye ekonomicheskie pokazateli gazodobyvayushchei promyshlennosti SSSR za 1961-1970" (The main economic indices of the gas-producing industry in the U.S.S.R. for 1961-1970). - "Ekonomika, organizatsiya i upravlenie v gazovoi promyshlennosti" (Economics, organization and management of the gas industry). Moscow, VNIIEgazprom, 1971; "Gosudarstvennyi pyatiletnii plan razvitiya narodnogo khozyaistva SSSR na 1971-1975 gg" (The State five-year plan for the development of the national economy of the U.S.S.R. in 1971-1975). Politizdat, 1972.

reserves in this region have been explored to the level of commercial categories. The development of gas production in this region is therefore bound up with the need to escalate geological exploration.

We cannot count on cheap production of gas under the difficult geological-economical and environmental-climatic conditions of developing deposits of the Komi A.S.S.R. and Arkhangel'sk Oblast (45% of the forecast reserves occur at a depth of 3,000 to 5,000 m). It must also be kept in mind that construction in the North (all other conditions being equal) requires twice the capital investment needed in the central zone, and that because of low temperatures and permafrost the standards and specifications for materials and components must be more stringent.

Centralization of production should be the key factor in effective development of northern gas deposits. The concentration of production in the largest deposits and moving the gas in large-diameter pipelines will ensure a significant reduction of capital investment in the development of the gas industry, as well as in ancillary industries. It will reduce the cost of delivering gas to distant consumers, and for domestic and community services in the newly developed settlements; it will considerably speed up and facilitate construction, and will improve the living and working conditions of the workers.

The gas transported from the large Vuktyl, Laya-Vozh and other deposits via a 1,220 mm pipeline (at a pressure of 75 atm) is "competitive" with Tyumen gas and is much cheaper than coal throughout the major industrial centres of the Northwest (Table III), even though the quoted cost of exploration and exploitation in this case is from 1.5 to twice that of the gas from Tyumen or Central Asia. The economic rationale for exploiting the relatively small deposits discovered in the Upper Pechora and Denisovka regions, must, however, be closely studied. Moreover, in doing so the specific conditions of production and utilization of the gas must be taken into account.

Most deposits in the Komi A.S.S.R. contain gas of a complex composition. The total extraction and utilization of all its valuable components

Table III

Estimated efficiency-adjusted cost of the prospective production and transport of gas and coal (as estimated by the author)

Place of consumption	Gas: Region of production	Gas: Efficiency-adjusted cost, rub/1,000 m³	Coal: Basin	Coal: Efficiency-adjusted cost, rub/ton
Ukhta	Komi A.S.S.R.	7.5		
Leningrad	Komi A.S.S.R.	11.1	Donets Basin	20.3
	Tyumen Oblast	15.8	Kuznets Basin (open-pit)	17.3
Kotlas	Komi A.S.S.R.	8.5		
Moscow	Komi A.S.S.R.	11.3	Donets Basin	18.4
	Tyumen Oblast	15.5	Kuznets Basin (open-pit)	16.5
Arkhangel'sk	Komi A.S.S.R.	10.4		
Petrozavodsk	Komi A.S.S.R.	12.6		
Murmansk	Komi A.S.S.R.	13.1		

increases economic efficiency in the exploitation of deposits.

In view of the proximity of the Timan-Pechora province to the large-diameter gas pipeline "Siyanie Severa" (Northern Lights), and because of the presence of promising off-shore reserves, consideration may be given to the intensified and accelerated exlpoitation of the deposits within shorter periods of time and with larger mean annual production of gas. This would enable us to increase the output of gas in the European regions, yet gain time for the preliminaries and extensive development of gas resources in more difficult or distant regions.

Taking into account the need to provide the maximum comfort for the population living under northern conditions, gas and electricity should be

the major sources of energy for cities and large industrial centres of the Komi A.S.S.R., Murmansk and Arkhangel'sk oblasts. It is therefore imperative to develop gas pipeline systems in this region.

All other conditions being equal, the use of gas in lieu of coal would yield a greater economic gain in the Northwest than in other parts of the European U.S.S.R. because of the high cost of coal.

Prospects for developing coal mining in the European North are somewhat different.

Large reserves of coal suited for power production and coking are concentrated in the Pechora Basin. Because of the difficult environmental and economic conditions prevalent in the region, the cost of coal mining is high. However, this circumstance is compensated for by the favourable geology and mode of occurrence of the coal seams facilitating exploitation. The cost of production of Pechora coals is therefore approximately at par with that of Donets coals. The transportation of Pechora coals to the major coal-consuming regions of the European U.S.S.R. (excluding the Komi A.S.S.R.) is, however, considerably costlier than the delivery of Donets coal to the same regions. For example, the estimated efficiency-adjusted cost for transporting one ton of reference coal from Inta to Arkhangel'sk is 1.5 times the cost of shipping a corresponding amount of coal from the Donets Basin. This is due to the superior quality of the latter, as well as to the higher cost of shipping by the northern route as compared to that via the southern routes, a circumstance accounted for, to a significant degree, by the uneven traffic patterns. The cost will eventually decrease, but will nevertheless be higher than on the southern routes because of the unfavourable climatic and economic conditions of the region. The Donets coals suited for power production, as well as the open-pit coals from the Kuznets Basin will therefore be cheaper here than Inta coals even in the future.

The special technical and economic calculations carried out by the Komi Branch of the Academy of Sciences, U.S.S.R. concerning the optimum use

of the Republic's fuel resources in the immediate future show that the utilization of the Inta high-ash coal is economically expedient only within the Republic.*

It would therefore not be expedient to expand the production of Inta fuel coal by building new mines with a view to shipping the coal outside the Komi A.S.S.R.

The scale at which Pechora coking coals are currently mined exceeds both the present and the future demand for the coal by the Cherepovets metallurgical plant. A portion of the Pechora coking coal mined can therefore be effectively used in metallurgical plants of the central regions.

The construction of new mines for coking coals in the Pechora Basin with a view to escalating their shipment outside of the northwestern region would, however, be uneconomical for the following considerations.

Large modern mines with optimum economic indices can be built only in the Vorgashorskoe field. The caking capacity of the Vorgashorskoe coal is, however, rather low. The research carried out to determine optimum mixtures for different plants of the central regions has therefore shown that in the Novolipetskii plant, Vorgashorskoe coal can replace only the abundant, cheapest grades of Donets gas coal. The supply of Kuznets coking coals to this plant will replace the expensive Donets coals of the OS, PZh and K grades at approximately the same cost as that of Vorgashorskoe coal.

We should add that the method of continuous coking, allowing the production of metallurgical coke from poorly caking Donets gas coal, will be intensively implemented in the future in the coke-chemical industry. It will then be possible to use as much as 50% of non-caking coals in the mixture.

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* A.F. Anufriev and A.A. Kalinin. Toplivno-energeticheskii balans Komi ASSR i metodicheskie predposylki ego optimizatsii (The fuel and power balance of the Komi A.S.S.R. and methodological premises for its optimization). - "Problemy razvitiya energetiki Severo-Zapada SSSR" (Problems of power-resource development in the Northwestern USSR). Riga, 1971.

Estimates have shown that it is much less economical to export Pechora coal than Donets anthracite. There are thus no economic premises for further developing the mining of the Pechora coking coal in the near future. The Basin will remain for a lenghty period of time the main source of coking coal for the Cherepovets metallurgical plant.

In summation, it should be stated that as a result of successful geological exploration during the last decade the power economy has altered substantially in the Komi A.S.S.R. and Nenetskii National Okrug of the Arkhangel'sk Oblast. Whereas in the past coal mining was the main fuel industry in these regions, oil and gas industries are now moving to the foreground and will increasingly gain in importance as time goes by. The region with the highest cost of fuel (among the European regions) will consequently become a zone with relatively inexpensive fuel. This will affect significantly the development and specialization of the resources in the region. The production of oil, gas, condensate, and associated gas will give rise to a new large base of hydrocarbon raw material. The availability of these resources in conjunction with the abundance of fresh water may serve as a basis for establishing a petrochemical industry in this area.

The authors believe that the possibility of supplying several tens of billions of cubic meters of gas and tens of millions of tons of oil to the European regions of the country insures an important place for the Timan-Pechora province in the fuel economy of the European U.S.S.R., its northwestern regions in particular.

MEETING OF THE BUREAU OF THE INTERDISCIPLINARY COMMISSION ON PROBLEMS OF THE NORTH

(PROBLEMS OF SETTLEMENT AND URBAN CONSTRUCTION IN THE NORTH)

The meeting of the Bureau of the Interdisciplinary Commission on Problems of the North, reporting to the Council for the Study of Resources, Gosplan, U.S.S.R., was held on June 8, 1972, under the chairmanship of Professor S.V. Slavin. The meeting examined problems related to settlement and urban development in the North with a view to conceptualizing the development and allocation of resources in the northern zone.

The meeting was attended by 60 representatives of 20 research or design institutes. Four papers and nine reports dealing with different aspects of settlement and urban development in the North were presented.

In his introductory address, S.V. Slavin noted the increasing importance of the problems of settlement and urban development in northern regions in relation to the development of new territories.

In his paper "The main trends in residential and civil construction in the regions of the North", A.V. Karagin, Director of the LenZNIIEP, reported on the designs for northern construction developed by the Leningrad Zonal Research Institute for Experimental and Model Design of Residential and Civil Buildings (LenZNIIEP).

In his paper "Systems of settlement in the North"*, L.A. Panov (LenNIIPgradostroitel'stva**), a Candidate of Architectural Sciences, demonstrated the advantages of system settlement in the North as compared to the conventional pattern of settlement in isolated centres or towns.

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* This paper, as well as certain other reports have been edited by the authors in the form of articles and appear in the present symposium.

** LenNIIPgradostroitel'stva = Leningrad Research Institute of Urban Design and Development. (Transl.)

Problemy Severa, (18): 240-243, 1973.

The paper read by V.G. Lazareva (LenZNIIEP) dealt with new types of residential complexes developed for northern regions. The speaker stressed the need for research on designing new types of buildings and working out various design solutions appropriate for the small populated centres prevalent in the North, but unusual for other parts of the country.

In her paper "Economic evaluation of new methods for developing human habitats in regions of difficult access", I.Yu. Murav'eva (LenZNIIEP) suggested methods for assessing the cost of appropriate habitats for northern dwellers. The cost thus calculated was used to estimate the relative efficiency of different patterns of settlement: the conventional pattern with one or two major towns (new or expanded), and the method of outposts with the base-resource town located in the zone of the deposits, or outside that zone.

A.M. Sachkov (TsENII* of the R.S.F.S.R. State Planning Committee) discussed in his report medical services for the population of northern regions and suggested a scheme for collecting statistics on the organization of therapeutic and preventive medical services provided for the population of a base region.

I.A. Gushchenko (Lengiprogor) noted that specialized research institutes should focus primarily on solving the unsettled crucial problems, such as: the relationship between the specialized, support, and service sectors; the use of the labour resources of the small northern ethnic groups, the principles of organizing the construction and location of local and southern construction bases; the development of scientifically substantiated standards and norms for consumption of food and other consumer goods, as well as for municipal and cultural services. The speaker believes it imperative to change from designing isolated settlements to the integrated design of groups of settlements or towns with a common transport system, common services, and a common industrial complex providing employment for the second member of the family, etc.

V.N. Antipin (Yakut Branch of the Siberian Division of the Academy of Sciences, U.S.S.R.) believes that in view of the progressively larger

* TsENII = Central Research Insitute of Economics. (Transl.)

scale of northern resource development, and because of the introduction of enterprises with a continuous annual production cycle (such as the Noril'sk Mining and Metallurgical Combine, the Yakut Combines for Diamond Mining, etc.), it is imperative to encourage and assist the growth of a permanent population and highly qualified personnel in the North. This implies stringent specifications for construction of large well-appointed settlements and towns. The speaker finds the development of northern resources by expeditions or outposts unacceptable because of the transient nature of the population involved when these methods are used.

I.S. Kir'yanova (Institute of General and Community Health of the Academy of Medical Sciences, U.S.S.R.) reported on the results of research on acclimatization and specific features of human life in the North carried out in 1955-1960 by the Institute of General and Community Health in cooperation with other institutes and medical services of the Glavsevmorput.* Results of the research were used as criteria for reviewing certain solutions in urban development, beginning with draft designs for residential and nonresidential premises, and ending with design specifications ensuring maximum comfort to the dwellers of urban centres in the North. A chart of public health requirements and specifications has been compiled, and the implementation of these specifications in northern urban development has begun.

The speaker emphasized, however, that significant changes in the social and demographic structure of the population, the nature of migration processes, and the growth of human needs over the last decade make it imperative to set up new integrated investigations and to develop new criteria for further development of the North.

As I.S. Kir'yanova pointed out, hygienic considerations are often at variance with the main economic requirements. In order to ensure the coincidence of the two, the methods of economic analysis, which so far have failed to take into account a number of important factors (social, psychological, physiological, etc.), must be improved.

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* Glavsevmorput = Main Administration of the Northern Sea Route. (Transl.)

G.O. Pavlyuchik (SibZNIIEP) raised three questions: a) the importance of northern problems; b) distinctive aspects of the methods and techniques employed to evaluate the solution of these problems; and c) the trends of the work of the Siberian Zonal Research Institute for Experimental and Model Design of residential and civil buildings intended for the North. The speaker believes that a number of the problems inherent to the North may also be characteristic of other regions (Northern Kazakhstan, Tuva A.S.S.R., Altai Krai), where climatic and economic conditions have many features in common with those of the northern regions. For example, by order of the State Committee on Civil Construction and Architecture reporting to Gosstroi,* U.S.S.R., six oblasts of Northern Kazakhstan have been included in the zone of jurisdiction of the SibNIIEP. In G.O. Pavlyuchik's opinion, the methods of economic analysis should provide estimates of the land-use factor and of the detriment resulting from mismanagement of land and water resources, as well as of the gain from high-quality resources and other factors.

E.Ya. Feigina (Giprogor) discussed specific aspects of regional planning for the North of Tyumen Oblast, where there is little economic development, inadequate exploration, and unstable focal element of planning, i.e., the economic justification for building towns. In the Central Ob region, where the prospective chart for developing an oil industry has been periodically revised, the economic base has been repeatedly "detached" from the settlements projected or under construction as a result of new discoveries of oil and gas deposits or because of the re-evaluation of the different zones in terms of their priorities for development. In the process, the estimated size of the population kept changing. This circumstance affected not only the projected structure of the region, but also that of individual urban formations. The above circumstances complicate design by introducing an additional element of uncertainty. Conventional urban development solutions prove unacceptable in this type of situation.

In regions of this kind it is expedient to apply new unconventional methods and patterns of settlement, in particular the "base town - shift-work camp" system, ensuring the maximum possible concentration of the population

* Gosstroi = State Committee for Construction. (Transl.)

within an urban settlement and providing for a system of satellite outpost settlements for those working in remote decentralized points. This proves to be the most flexible system of settlement best "adapted" to the unstable town-forming base, such as extracting industries.

It also appears expedient to follow a dynamic system of settlement providing for a stage-by-stage development of the settlement in the process of formation, hence variation, of the economic base.

E.Ya. Feigina believes that it is premature to develop permanent settlements on the basis of geological exploration camps before the geological information has reached the required level to determine whether commercial exploitation of the given deposits is economically justifiable. For example, Gornopravdinsk, a well-appointed settlement on the Irtysh River, was built to accommodate geological expeditions. The future of this settlement is now obscure, since its economic base (i.e., geological explorations) will soon be relocated to new regions of prospecting, and since "substitute" industries or enterprises can scarcely be expected to succeed in such a remote settlement.

The speaker believes that the initial stage of settlement, corresponding to the unstable early developmental level of the economic base, should be in the form of temporary camps consisting of standard modules (mobile or relocatable). The second evolutionary stage of a dynamic system of settlement is the introduction of the "base town - shift-work camp" system. The experiment in urban development in Nadym can be used to draw a number of significant conclusions for the evaluation of this system. Nadym has been designated as the base town from which groups of workers would be delivered to satellite outposts. The experiment will enable us to study a number of specific features (technological, socio-economic, etc.) inherent in this system of settlement.

G.S. Shur (LenNIIPgradostroitel'stva) suggested that the Urban Development Division of the U.S.S.R. State Planning Committee and the State Committee for Civil Construction and Architecture, reporting to Gosstroi, U.S.S.R., on behalf of the Interdisciplinary Commission on Problems of the North, be requested to work out a plan for coordinating the main design works intended for

the northern zone. In G.S. Shur's opinion the shift-work camp pattern is the most appropriate solution for regions with extreme climatic conditions unsuitable for permanent settlement. Base cities should not, however, necessarily be situated in the southern regions; it is preferable to locate them closer to the regions of the shift-work development in the zone of the Near North.

A.V. Kochetkov (TsNIIP of urban development) emphasized the complex nature of the problems related to settlement in the North and provided the rationale for multidimensional evaluation in choosing one or another variant of settlement: systems analysis, identification of objectives and criteria for quantitative measurements, specific technical and economic calculations and economic forecasting.

A.V. Yakovlev and O.A. Bronskaya (LenZNIIEP) reported on the main trends of the research, conducted by the LenZNIIEP Division for planning and developing residential complexes and settlements, on problems related to designing populated centres in the northern zone of the country. In recent years the Division carried out a number of research projects, results of which have been published in the reference album "Arkhitekturno-stroitel'noe raionirovanie territorii Severa" (Architectural and Construction Regionalization of the Northern Territory) and "Metodicheskie ukazaniya po uchetu klimata i gradostroitel'nogo regulirovaniya - mikroklimata pri proektirovanii naselennykh mest v Severnoi zone strany" (Instructions of the Methods Taking into Account the Climate and the Regulatory Effect of Urban Development, i.e. Microclimate, in Designing Populated Centres for the Northern Zone of Our Country). To solve the problems facing the Division, a broad spectrum of research must be organized. These problems are as follows: to forecast the development of resources, supply, services, and a transportation system in the northern zone of our country; to identify the social and psychological requirements for organizing human habitats in the populated centres of the North; to define inadmissible climatic parameters, as well as comfort factors, for different regions of the North; to control physical environment parameters in populated northern centres; to explore the possibility of improving the microclimate in northern populated centres by using the heat from the earth's interior, wind energy, tidal power and other kinds of renewable energy.

Concluding the work of the sessions, S.V. Slavin noted the disparity in the extent to which the problems examined have been studied. The feasibility of system settlement under northern conditions has been studied for many years by the LenNIIPgradostroitel'stva; results of this research may now be expected to appear in the form of major publications. Discussions have shown, however, that the shift-camp method of developing the North has been inadequately studied so far. There is in fact no point of departure for working out this problem: fundamental technical and economic substantiations and calculations, medical and sociological conclusions are needed. The search for optimum solutions on northern settlement must be differentiated with reference to different regions of the northern zone. The State Committee on Civil Construction and Architecture reporting to Gosstroi, U.S.S.R. should play a major role in solving northern settlement and urban development problems, since the lack of research coordination with respect to the problems discussed is evident. Preparing experimental designs for several types of towns and settlements intended for different regions of the North will enable us to build northern towns with greater assurance.

In conclusion, S.V. Slavin suggested holding, in 1974, a conference on the topical problems of northern settlement and urban development.

N. Glabina

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THE COMMISSION ON PROBLEMS OF THE NORTH AFFILIATED WITH THE PRESIDIUM OF VASKhNIL*

In order to achieve scientific and methodological supervision and coordination of research in agriculture and renewable resource in the Far North, a Commission on Problems of the North was created in 1936 under the authority of the Presidium of VASKhNIL. In 1953 the Commission temporarily suspended its operations.

As a result of the further expansion of agricultural production in the regions of the Far North, and because of scientific advance, a sharp need arose for intensifying continuous scientific and methodological supervision and coordination of the research conducted.

In 1966 the VASKhNIL Presidium therefore agreed with the proposal of the SOPS Interdepartmental Commission on Problems of the North, Gosplan, U.S.S.R., and reactivated the VASKhNIL Commission on Problems of the North.

In 1968, upon instruction of the VASKhNIL Presidium, the Commission on Problems of the North, in cooperation with the Interdepartmental Commission on Problems of the North, Gosplan, U.S.S.R., prepared a draft plan for the development of agricultural sciences in the North until 1980.

In November 1968 the Plenum of the Commission on Problems of the North, affiliated with the VASKhNIL Presidium, reviewed and approved the major trends of research aimed at studying biological resources and prospective development of northern agriculture and renewable resource industries. This documentation was recommended to northern research institutions for guidance

* VASKhNIL = The All-Union Lenin Academy of Agricultural Sciences. (Transl.)

Problemy Severa, (18): 244-245, 1973.

in working out research themes and projects during the ninth five-year-plan period.

Several important scientific and managerial conferences on the development of far-northern agricultural production have been held on the initiative of the Commission and with its active participation. These included the following conferences: a) on the development of agriculture in Magadan Oblast, held in Magadan in 1969; b) on the development of flood plains in the Tomsk region adjoining the Ob River, held in Tomsk in 1970; c) on major trends in and tasks for agricultural sciences for 1971-1975, held in Novosibirsk in 1970; d) on the development of animal husbandry in Siberia and in the Far East, also held in Novosibirsk in 1970; e) on the rational use and protection of wild reindeer resources, held in Dudinka in 1971; and f) on developing local food production in industrial regions of the North, held in Noril'sk in 1972.

The Commission on Problems of the North took an active part in the activities of the Plenum of the SOPS Interdepartmental Commission on Problems of the North, Gosplan, U.S.S.R., in organizing the symposium on reindeer breeding that was held in Finland in 1971, as well as in publishing a number of monographs dealing with northern agriculture and traditional, biological industries, which have been favourably reviewed both in our country and abroad.

The Interdepartmental Commission on Problems of the North, Gosplan, U.S.S.R., with the participation of the Commission on Problems of the North affiliated with the VASKhNIL Presidium, published in 1967-1968 two monographs - "Sel'skoe i promyslovoe khozyaistvo Severa SSSR" (Agriculture and traditional industries in the North of the U.S.S.R.) and "Promyslovaya fauna Krainego Severa i ee ispol'zovanie" (Harvesting wildlife resources of the Far North). Both monographs have been translated into English and published in Canada. In 1969 the Plenum of the Commission on Problems of the North, affiliated with the Presidium of VASKhNIL, published documentation concerning the major trends and results of research on biological resources and development of northern agriculture and traditional industries.

The first volume of the monograph, "Sel'skokhozyaistvennoe

osvoenie Severa SSSR" (Agricultural development in the North of the U.S.S.R.), is now in print; the second volume, "Sel'skoe i promyslovoe khozyaistvo Severa SSSR" (Agriculture and traditional industries in the North of the U.S.S.R.), is in preparation.

At the May 31, 1972 session of the VASKhNIL Presidium it was noted that the development of northern agriculture and traditional industries is still lagging behind the rapidly growing demand of the population for food products. Shortcomings have been recorded in the scientific and methodological supervision of research coordination in the Far North, carried out by scientific institutions affiliated with different Ministries.

The VASKhNIL Presidium defined the main task of the Commission on Problems of the North to be the realization of scientific and methodological supervision and coordination of research on agriculture and traditional industries that is conducted in the Far North by agricultural research institutions, institutes of the Academy of Sciences, U.S.S.R., universities, and other institutions of higher learning, regardless of their ministerial affiliation. The Commission was requested: a) to summon in 1973, in cooperation with the Academy of Sciences U.S.S.R., the Siberian Division of VASKhNIL and the Ministry of Agriculture of the R.S.F.S.R., a coordination conference on implementing the resolution of the VASKhNIL Presidium of November 15, 1968 (The major trends in research on biological resources and on the prospective development of agriculture and traditional industries in the North of the U.S.S.R., up until 1980); and b) to define the further course of research and development.

The VASKhNIL Presidium approved the new membership of the Commission on Problems of the North, numbering 74. These include: 8 full members of VASKhNIL, 3 corresponding members of the Academy of Sciences, U.S.S.R., 3 corresponding members of VASKhNIL, 21 doctors of sciences, and 25 candidates of sciences. The Commission includes representatives from the State Planning Committees (Gosplans) of the U.S.S.R. and R.S.F.S.R., State Committee of the Council of Ministers of the U.S.S.R. for Science and Technology, Council of Ministers of the R.S.F.S.R., Academy of Sciences of the U.S.S.R., Ministries of Agriculture of the U.S.S.R. and R.S.F.S.R., and from a number of institutions

of higher learning.

E.E. Syroechkovskii, a doctor of biological sciences, has been appointed President of the Commission. The Vice-Presidents are: G.G. Antiokh, a candidate of sciences, Assistant Chief of the Main Administration for Agricultural Sciences and Propaganda of the R.S.F.S.R. Ministry of Agriculture, S.F. Zhdanov, Chief of the Northern Administration, Ministry of Agriculture, R.S.F.S.R., and P.N. Vostryakov, a candidate of agricultural sciences, Scientific Secretary of the Central Research Institute on Economics, Gosplan, R.S.F.S.R.

Working plans of the Commission on Problems of the North provide for measures in the scientific and methodological supervision of research in far-northern agriculture and traditional industries, for holding scientific and managerial conferences, and for other activities. A conference dealing with "The wild reindeer in Taimyr" was held in Moscow in February 1973, and another conference on "The main paths for developing northern reindeer breeding and the tasks facing the science" was held in March 1973, in Salekhard.

V. Fedotov

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